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EDITORIAL

Agricultural Mechanization in Malaya.

This issue of the *Malayan Agricultural Journal* is in the form of a Special Mechanization Number and is complementary to the first such number published in January, 1948. It records the extensive work carried out by the Department of Agriculture during the past eighteen months, in spite of the serious shortage of senior staff, in its investigations into the application of mechanization to Malayan agriculture. These investigations have covered a wide field, but the greatest proportion of time and effort has been concentrated on the possibilities of improving rice cultivation by mechanical methods. This is logical since the improvement of padi yields and the opening up of large new areas for padi cultivation in order to make Malaya less dependent on outside sources of supply have always been foremost in the activities of the Department.

Before readers study the detailed reports of investigations into the mechanical cultivation of padi, we recommend them to read the general review of these investigations written by Mr. C. W. S. Hartley, Acting Senior Agricultural Officer, Research.

Mr. Hartley draws attention to three sets of problems which are involved, two of which are of immediate importance: agronomic and engineering. The first is concerned with agricultural methods, while the second relates to the purely mechanical difficulties to be surmounted. The third set of problems is social and economic and will arise only when mechanization is in process of establishment on a considerable scale.

Certain types of tractors and implements have now been successfully operated in deep peat areas and on clay soils of firm bottom, and cultivation has been successfully carried out in the latter areas both under dry and flooded conditions.

It is in the development of new large areas of padi land that mechanical cultivation is likely to prove of most value. As far as the existing padi areas are concerned the present system of ownership involves numerous small individual plots which make large-scale mechanization difficult. Only if considerably increased crops are shown to be obtainable as the result of mechanical cultivation would a change in the system be likely to appeal to the cultivator.

Further investigations have been carried out into the felling and disposal of old oil palms by mechanical methods, of which an interesting demonstration was given at the Federal Experiment Station, Serdang, in January 1948, as part of a general demonstration of mechanical equipment. Two mechanical methods have been tried, by bulldozer and by a cable drawn by two tractors. The former method has been found to be preferable, but it is pointed out in an article in this issue that both methods would be considered only by contractors or firms operating on a very large scale owing to the high cost of depreciation and repairs, and for the average estate poisoning of palms will prove the most satisfactory method of disposal.

The removal of rubber stumps by mechanical means was described in the previous Special Mechanization Number of this Journal (January 1948), and an article in the present issue describes further investigations into the mechanical clearing of felled rubber land. Stumping, piling, and rooting, were all carried out successfully by tractors and various implements. The maintenance of machines is clearly an extremely important factor in work of this nature and mechanization could be adopted only by a large undertaking able to maintain the essential staff of mechanics and trained operators.

The application of mechanical methods to lalang eradication is of wide interest since the rapid growth of lalang has always been a major problem in Malayan agriculture, and particularly so since the war. With the present high cost of labour, hand methods of eradication are very expensive, and articles in this issue show that costs can be reduced considerably by the use of mechanical equipment either for spraying sodium arsenite or for eradication by tillage. The latter method is the more economical owing to the quantity of sodium arsenite required as a spray.

From a study of the various articles in this issue readers will appreciate the complex problems which have to be faced and solved in adapting to tropical conditions mechanical equipment designed principally for agricultural operations in temperate climates. They will also appreciate the amount of work that has already been carried out in investigating these problems, and that the problems are still far from being completely solved. As has already been said, the most important application of mechanization in Malaya is to padi cultivation, and, here, progress is dependent on the solution of engineering and agronomic problems linked with the development of new areas into which mechanical equipment can be satisfactorily introduced.

INVESTIGATIONS INTO THE MECHANICAL CULTIVATION OF WET PADI 1948-1949.

A General Review

BY

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Mechanical cultivation of wet padi presents a very much more difficult problem in Malaya than in countries such as the United States and Australia where it has already been successfully practised. In such countries the land is usually cultivated when dry, and sowing may be carried out either by drilling in slightly moist soil, followed by irrigation, or by broadcasting (usually from aircraft) over already flooded areas.

In Malaya the rainfall is heavy and erratic, and such drainage works as have been constructed are rarely capable of removing immediately the large quantities of rainwater which may fall in a very short space of time. It is thus not possible to be certain that the land will be dry at the time when cultivation should be carried out, and it is therefore necessary to be prepared to cultivate on wet or even on flooded land. On peat lands and others lands with no firm bottom, cultivation in the wet is unlikely to be possible, but the soil is so soft at the best of times that special means must be devised for pulling implements, and in any case it is obviously of advantage to have equipment which will enable tractors and implements to get on the land at the earliest possible moment after wet weather.

With these considerations in mind, investigations were started during the 1947-48 season and the work done was described in a previous number of this Journal*. A very restricted number of tractors and implements was available during that season and, as was pointed out at the time, investigations were only exploratory, that is to say they were intended to show how far the tractors and implements available could be operated under Malayan conditions, and from this it was hoped to gain some idea of the lines on which future work should proceed.

Work during the 1947-48 season was carried out mainly in Province Wellesley(1) and in the Sungei Manik area of Lower Perak(2). In the former area trials were conducted on the inland soils of firm bottom clay. It was soon apparent that wheeled tractors were more suitable than track-tractors and, while ploughing was comparatively easy under both wet and dry conditions, after-cultivation, i.e. harrowing and rolling, was much more difficult. In the Sungei Manik area the trials were carried out on soft peat and muck soils over-lying clay. Wheeled tractors, track-tractors and

* *Malayan Agricultural Journal*, January, 1948.

military Weasels (amphibious cargo carriers) were tried but none of these machines was successful as it stood, and it soon became clear that although track-tractors were likely to be more successful than wheeled tractors in areas of this type their tracks would require considerable enlargement and modification. Some modifications made to a Caterpillar D.4 tractor that season enabled cultivation to be carried out with disc-ploughs and cut-away disc-harrows.

1948-49 Season.

It was recognised from the start that two sets of problems are involved in attempting to introduce mechanical cultivation of wet padi. Firstly there are the agronomic problems, that is to say problems concerning the methods of cultivation to employ and their effect on the padi crop. Secondly there are the purely constructional and engineering problems: the discovery of the most suitable tractors and implements to do the work, and where necessary the modification of these to suit the particular conditions under which they are to be employed. There is, of course, a third set of problems, social and economic, which will have to be faced when work on the first two sets of problems has reached a stage where the introduction of mechanical cultivation on a large scale becomes practicable. The first two sets of problems are, however, the ones for immediate research.

It was considered that the investigations carried out during the 1947-48 season were sufficiently promising to enable a limited number of agronomic experiments to be started. Experiments were laid down in Province Wellesley, Malacca and Kelantan to find the effect on the subsequent padi crop of: (a) carrying out mechanical cultivation at different depths and at different times, and (b) planting inter-season crops. These experiments are described in later articles in this number of the Journal. In the Sungei Manik area, on the peat soil, it was considered that cultivation experiments of this type would be of little value, and experiments were confined to problems of planting distance and weed control.

With regard to the engineering work the 1947-48 trials had shown that in the peat areas or in areas where there was no firm bottom new tracks would have to be evolved which would make it possible to 'float' the heavy track-tractors so that they could pull implements without becoming bogged down. This has been the main problem under investigation in the Sungei Manik area during the past season, and the considerable progress made is described in detail in a later article.

In Province Wellesley and Kelantan, where padi fields with a firm bottom predominate, it was expected that the cultivations following ploughing would present the greatest problem. In Malacca a successful attempt was made to carry out all work in the dry and to introduce water only after drilling. In Province Wellesley great progress was made with the evolution of wheels and implements which would enable post-ploughing cultivations to be carried out in the wet. The measure of success attained

can be gauged from the fact that there was a demand from local padi planters for their padi fields to be mechanically cultivated, and over 46 acres were ploughed for them.

Details of the work carried out in the firm-bottom areas are given in other articles, and it is proposed here to discuss the results obtained and to present in collected form data showing the rate of work, fuel consumption, etc. of a number of cultivations carried out in these areas.

Tractors.

In Province Wellesley, Kelantan, and Malacca the Fordson Major has been the tractor employed for the majority of the work. A Farmall 'A' was employed for some work in Province Wellesley and Kelantan but it is not considered that it is sufficiently high-powered for wet land work.

For operations in wet conditions it was soon apparent that special wheels or extensions would have to be designed. Other makes of tractor with suitable wheels had not arrived in time for trial in the 1948-49 season.

Wheels.

As far as dry land cultivation is concerned standard Fordson steel wheels have proved very efficient, the off-set lugs assisting in the self-cleaning of the wheels. In Kelantan, on the hard pan areas, these wheels were quite adequate for initial ploughing in flooded conditions, and in two areas after-cultivation was completed with these wheels. In most areas, however, post-ploughing cultivation presents the greatest problem and the evolution of wheels which would enable the tractors to draw harrows and rollers over ploughed and flooded land has been the main problem. In Province Wellesley two different types of wheels were used, and by fitting these wheels, after-cultivation in flooded conditions became possible. Perhaps the most interesting feature of this work has been the clear demonstration that differences of soil exist, even within the hard pan areas, which demand the use of different wheels.

At the present moment it is not possible to ascertain except by trial which wheels will be suitable for any particular area, and a study of the soil in its relation to the operation of tractors is clearly required.

Implements.

Ploughs.

In the peat areas no satisfactory disc-plough has yet been used. Mould-board ploughs are, of course, out of the question owing to the roughness of the land and the presence of snags. The most successful cultivation has been done with a cut-away disc-harrow weighing 1,563 lbs. (McCormick-Deering Cutaway 19B). In the hard pan areas mould-board ploughs have worked quite satisfactorily and disc-ploughs have only been used with the Farmall 'A' tractor. Disc-ploughs are normally only preferred where running conditions make it difficult for a mould-board plough to operate smoothly and without interruption. Both integral and trailer type mould-

Table I. Mechanical Cultivation by Four-Wheeled Tractors in Malacca, Kelantan and Province Wellesley.

Conditions of Working	Type of Land	Location	Tractor	Wheels	Implement	Acreage Covered	Acreage and Fuel Consumption per Running Hour		Fuel per Acre	Remarks
							Acres	Galls. T.V.O.	Galls. T.V.O.	
I. PLOUGHING.										
1. Dry ..	Grey clay with variable pan 6 to 12 ins.	P. Gadong, Malacca	Fordson	Standard steel ..	McD. 2-furrow mould-board plough	3.17	0.49	1.2	2.5	
2. -do- ..	Redish brown clay	K. Bharu, Kelantan	-do-	-do-	Power-lift 3-furrow	0.38	0.22	2.5	11.3	8 ins. depth.
3. -do- ..	with definite pan at	-do-	-do-	-do-	mould-board plough	0.50	0.26	2.2	8.5	4 ins. ,,
4. -do- ..	about 5 ins. below	-do-	-do-	-do-		0.63	0.19	2.0	11.0	8 ins. ,,
5. -do- ..	surface ..	-do-	-do-	-do-	-do-	0.63	0.35	2.8	8.0	4 ins. ,,
6. Wet standing water ..	Redish brown clay in	Salor, Kelantan ..	-do-	-do-	-do-	0.55	0.38	3.3	8.6	4 to 6 ins. depth.
7. -do- ..	a soft area which usually has standing water but with firm bottom at 6 ins. ..		-do-	-do-	-do-	0.25	0.42	3.9	9.4	-do-
8. -do- ..	Even padi land with pan at 4 to 6 ins.	Kg. Bila Dua and Sg. Derhaka, Province Wellesley ..	-do-	Solid type extension wheels front and rear	McD. 2-furrow mould-board plough	34.90	0.36	2.4	6.7	
9. Dry, semi dry to wet ..	Variable and uneven with sticky and deep portions ..	Sg. Derhaka, Province Wellesley ..	-do-	-do-	-do-	11.64	0.33	2.4	7.3	
10. Wet ..	See 6 ..	Salor, Kelantan ..	Farmall 'A'	Serdang-made steel wheels ..	2-furrow integral disc-plough	0.42	0.17	1.2	7.0	-do-
II. DISC HARROWING.										
11. Dry ..	See 1 ..	P. Gadong, Malacca	Fordson	Standard steel ..	Martin disc-harrow (complete)	3.13	0.15	1.2	8.1	Land covered 8 times.
12. Moist, ¼ acre wet and sticky ..	See 2-5 ..	K. Bharu, Kelantan	-do-	-do-	Martin disc-harrow (front half)	2.25	0.22	2.3	10.3	Land harrowed until tilth obtained.
13. Wet ..	See 6-7 ..	Salor, Kelantan ..	-do-	-do-	-do-	0.67	0.85	3.1	3.6	Land harrowed till puddled.
14. -do- ..	See 9 ..	Kg. Bila Dua, P. Wellesley ..	-do-	Solid type extension	McD. light harrow (front half)	5.54	0.69	2.0	3.0	-do-
III. ROLLING.										
15. Semi-wet ..	See 9 ..	-do-	-do-	-do-	Double Kedah iron roller	3.92	0.77	2.4	3.1	
16. Wet ..	See 9 ..	Sg. Derhaka, Province Wellesley ..	-do-	-do-	Single Kedah iron roller	11.64	0.64	1.9	2.9	
17. -do- ..	See 9 ..	Kg. Bila Dua, P. Wellesley ..	-do-	-do-	Drum roller	11.88	1.30	3.0	2.3	
IV. ROTARY CULTIVATION.										
18. Wet ..	See 8 ..	-do-	-do-	-do-	Tillmore T.28	3.50	0.53	2.1	4.0	
19. -do- ..	See 9 ..	-do-	-do-	-do-	-do-	5.49	1.28	1.8	1.4	
V. DRILLING.										
20. Dry ..	See 1 ..	P. Gadong, Malacca	-do-	Standard steel ..	Disc drill	3.13	1.04	1.3	1.2	
VI. CATTLE PLOUGHING.										
21. Moist ..	See 2-5 ..	K. Bharu, Kelantan	—	—	Kel. plough	1.00	0.06	—	—	1st ploughing.
22. -do- ..	See 2-5 ..	-do-	—	—	-do-	1.00	0.06	—	—	2nd ,,
23. Wet ..	See 6 ..	Salor, Kelantan ..	—	—	-do-	0.21	0.06	—	—	1st ,,
24 -do- ..	See 6 ..	-do-	—	—	-do-	0.21	0.05	—	—	2nd ,,
VII. BUFFALO PLOUGHING.										
25. Wet ..	See 1 ..	P. Gadong, Malacca	—	—	Malacca plough	1.43	0.04	—	—	
VIII. CATTLE HARROWING.										
26. Moist ..	See 2-5 ..	K. Bharu, Kelantan	—	—	Kel. harrow	1.00	0.11	—	—	1st harrowing.
27. -do- ..	See 2-5 ..	-do-	—	—	-do-	1.00	0.04	—	—	2nd ,,
28. Wet ..	See 6 ..	Salor, Kelantan ..	—	—	-do-	0.21	0.06	—	—	1st ,,
29. -do- ..	See 6 ..	-do-	—	—	-do-	0.21	0.05	—	—	2nd ,,
IX. BUFFALO HARROWING.										
30. Wet ..	See 1 ..	P. Gadong, Malacca	—	—	Malacca harrow	3.00	0.15	—	—	

Note: T.V.O. = Tractor vaporising oil.

board ploughs have been tried and, although the integral power-lifted plough has not worked entirely satisfactorily owing to difficulty in adjusting for depth, it is thought that the advantages of power-lifted implements are very great and that attempts should be made to have all cultivations carried out by them. One of the chief sources of trouble in a padi field has been the difficulty in negotiating the head-lands with trailer implements, and if the implements can be raised when the tractor is turning, this difficulty should be largely overcome.

After-Cultivation.

A series of implements was evolved in Province Wellesley which enabled the land to be worked down to a puddled state similar to that produced by buffalo-drawn harrows and rollers. Consideration will, however, have to be given in future to whether such thorough cultivation and puddling are necessary. Work in Kelantan has suggested that much mechanical stirring of the soil may be followed by increased weed growth, and it may be found that one or more good ploughings, in which the furrow-slices are properly inverted, followed by a minimum of after-cultivation (say by slicing the ridges with discs) may be sufficient.

Rate of Work and Costs.

Table I shows the rate of work and fuel consumption for a number of cultivations carried out in Province Wellesley, Kelantan and Malacca. In Sungei Manik, as previously mentioned, a great majority of the work was carried out with a cut-away disc-harrow pulled either by a Caterpillar D.4 tractor or by an International Harvester T.D.6. The rate of work was normally 1 acre per hour and running costs were $1.41 per acre. The total cost of four such cultivations and drilling (including seed) worked out at $17.05, excluding depreciation and repairs.

In the hard pan areas (Table I) the rate of work per running hour must be considered quite satisfactory both under dry and wet conditions. A direct comparison with mould-board ploughs working in dry land non-padi areas is not possible since these ploughs are usually very unsatisfactory in the conditions of rough vegetation which usually obtain in such areas. A comparison of this padi land mould-board ploughing with disc-ploughing by ploughs of similar width used in dry land areas is quite favourable to the mould-board ploughs. The usual rate of work for disc-ploughing has been 0.4 to 0.6 acres per hour, giving a daily rate (with 6½ hours running time) of between 2½ and 4 acres. If tractors and implements are to be properly maintained they cannot be kept running for more than about 6½ out of the total 8 hours working day unless overtime payments are made or operators are employed on a shift system. It is usually considered that one operator with a labourer comprise the minimum necessary team per tractor. This costs over $5 per day or about 80 cents per running hour. It is not, however, always possible to keep tractors at work even for 6½ hours, and in the ploughing of 35 acres in Province Wellesley (Table I,

Table II.

Costs of Mechanical Cultivation of Wet Padi Land in Firm-Bottom Areas.

Highest and Lowest Expected Costs of Ploughing and Harrowing under Wet and Dry Conditions.

Condition of Land	Implements*	Costs per Running Hour				Costs per Acre			
		T.V.O.	Depreciation, Repairs, Starting Petrol and Lubricants	Labour	Total	T.V.O.	Depreciation, Repairs, Starting Petrol and Lubricants	Labour	Total
		$	$	$	$	$	$	$	$
Dry ..	2.3 furrow mould-board ploughs	1.00-2.00	1.00-1.25	0.80-1.00	2.80-4.25	2.00-5.00	2.00-2.50	1.60-2.50	5.60-10.00
Wet ..	-do-	2.00-3.00	1.00-1.50	0.80-1.50	3.80-6.00	5.00-9.00	2.50-4.50	2.00-4.50	9.50-18.00
Dry ..	Disc-harrowing with light disc-harrows†	1.00-1.50	1.00-1.25	0.80-1.00	2.80-3.75	4.00-9.00	4.00-7.50	3.20-6.00	11.20-22.50
Wet ..	-do-	1.50-2.50	1.00-1.50	0.80-1.50	3.30-5.50	2.00-7.50	1.30-4.50	1.00-4.50	4.30-16.50

* with Fordson Major tractor throughout.

† work continued until requisite tilth or puddling is obtained.

item 8) the total labour costs were $125.16, which indicates 23½ days work or an average of just over 4 hours running time per day. Although, therefore, acreage per running hour may already be regarded as quite satisfactory, incidental difficulties, such as minor breakdowns, the negotiation of difficult patches in the padi fields and heavy rain, reduce the acreage per day considerably. There is every hope, however, that with increasingly efficient wheel and implement design most of these incidental difficulties will be overcome. Until they are overcome, however, a single tractor can only be expected to deal with about half to two-thirds of the area it could deal with if it were in uninterrupted operation for 6½ hours per day.

Fuel Consumption.

This is, in most cases, a good deal higher than in similar dry land cultivations where the consumption of T.V.O. (tractor vaporising oil) with a Fordson Major and plough is usually about 1.4 gallons per running hour. Consumption in Malacca, however, has been lower than elsewhere, and it therefore appears that the work there, under dry conditions, may have been somewhat lighter than the work under similar conditions in Kelantan. It is fairly clear, however, from the work done in the larger areas in Province Wellesley, that fuel consumption is likely to be 50 to 100 per cent. higher in wet padi land under damp or flooded conditions than on dry land, and this is hardly surprising. T.V.O. costs may therefore vary in wet land from $2 to $3 per running hour or about $5.50 to $9 per acre when ploughing. With depreciation, repairs, starting petrol and lubricants added, these figures become approximately $3 to $4.50 per running hour or $8 to $13.50 per acre when ploughing.

Table II gives some highest and lowest expected costs of ploughing and harrowing with Fordsons under dry and wet conditions. This table is intended only as a guide to the probable range of costs of the methods of cultivation so far employed. An interesting feature of this table is that it shows that land ploughed in the dry required considerably more breaking down than land ploughed in the wet. It should be noted that the costs per acre are based on an assumption of 6½ running hours per day.

Market Garden Tractors.

Much interest has been shown in the possible use by padi planters of cheap, two wheeled market garden tractors. Trials with the Gem Rotary Hoe, Trusty Tractor, and the B.M.B. Plowmate were carried out in Province Wellesley and in Kelantan, and in the case of the Rotary Hoe and the Plowmate special open work wheels were fitted. Table III gives some details of work carried out by these tractors in trial plots. It will be noted that mechanical cultivation by these implements has rarely been more than twice as fast as cultivation with cattle, though a comparison with buffaloes would no doubt be more favourable to the tractors. Fuel consumption figures per hour show the Trusty to have been superior in this respect to the Rotary Hoe and the Plowmate, but in all cases the cost of fuel must

Table III.

Mechanical Cultivation by Small Two-Wheeled Tractors in Kelantan and Province Wellesley.

	Tractor	Wheels	Implement	Location	Conditions of Working	Area Covered	Working Time per Acre	Acreage and Fuel Consumption per Running Hour		Fuel per Acre	Remarks
						Acres	hours	acres	galls. petrol	galls. petrol	
1.	"Gem" Rotary hoe	Standard Steel ..	—	K. Bharu, Kelantan	Moist soil (¼ acre sticky ..	0.75	19.0	0.05	0.47	9.0	First cultivation.
2.	-do- ..	Wide open-work ..	—	-do- ..	4 ins. water ..	0.75	9.3	0.11	0.55	5.1	Second ,,
3.	-do- ..	-do- ..	—	-do- ..	-do- ..	0.75	6.7	0.15	0.55	3.7	Third ,,
4.	-do- ..	-do- ..	—	Bk. Merah, P.W. ..	2 to 3 ins. water medium deep land	2.10	7.9	0.13	0.61	4.8	First ,,
5.	-do- ..	-do- ..	—	-do- ..	-do- ..	0.79	7.6	0.13	0.71	5.4	Second ,,
6.	-do- ..	-do- ..	—	-do- ..	Deep land 2 to 3 ins. water ..	0.53	7.5	0.13	1.06	8.0	
7.	-do- ..	-do- ..	—	-do- ..	Shallow land 2 to 3 ins. water ..	0.25	6.0	0.17	1.33	8.0	
8.	B.M.B. Plowmate	Standard Steel ..	Plough ..	K. Bharu, Kelantan	Moist soil ..	0.75	12.6	0.08	0.40	5.0	1st ploughing.
9.	-do- ..	-do-	Disc-harrow ..	-do- ..	Rather wet and sticky	0.75	6.7	0.15	0.38	2.5	1st harrowing.
10.	-do- ..	Open-work 9 ins. wheel ..	Plough ..	-do- ..	Sticky with some surface water ..	0.75	19.5	0.05	0.37	7.2	2nd ploughing after harrowing.
11.	Trusty ..	Standard (alternate lug) ..	Plough ..	-do- ..	Moist soil ..	0.75	16.6	0.06	0.32	5.4	1st ploughing.
12.	-do- ..	-do- ..	Disc-harrow ..	-do- ..	Rather wet and sticky	0.38	9.6	0.10	0.31	3.0	1st harrowing.
13.	-do- ..	-do- ..	Toothed harrow ..	-do- ..	-do- ..	0.38	3.1	0.32	0.42	1.3	1st harrowing.
14.	-do- ..	-do- ..	Plough ..	-do- ..	Sticky with some surface water ..	0.75	7.8	0.13	0.49	3.8	2nd ploughing.
15.	-do- ..	-do- ..	Toothed harrow on bogey ..	-do- ..	4 ins. water ..	0.75	13.2	0.08	0.39	5.2	2nd harrowing.
16.	Cattle and Kelantan plough			-do- ..	Moist soil ..	0.75	14.4	0.07	—	—	1st ploughing.
17.	-do-	harrow		-do- ..	Rather wet ..	0.75	8.6	0.12	—	—	1st harrowing.
18.	-do-	plough		-do- ..	Sticky with some surface water ..	0.75	14.8	0.07	—	—	2nd ploughing.
19.	-do-	harrow		-do- ..	4 ins. water ..	0.75	23.0	0.04	—	—	2nd harrowing.

be regarded as very high and it is clear that if these machines are to be suitable for wet padi work the efficiency of operation and the rate of work must be considerably increased. Further trials with these and other small machines are envisaged but it cannot at present be said that they are very promising.

Future Experimental Programme.

Investigations into the mechanical cultivation of wet padi have now reached the stage where success has been attained in the operation of certain types of tractors and implements both in the deep peat areas and on the firm bottom areas. In the latter, cultivation has been successfully carried out both under dry and under flooded conditions. Successful operation of these tractors and implements made it possible during the last season to start agronomic experiments.

It is realised that much more is likely to be gained by the introduction of mechanical cultivation into new areas than by its introduction into already established areas. The majority of areas likely to be opened in the future are areas with peat soil or other soils having no firm bottom. It has been decided, therefore, that first priority shall be given to the work being carried out at Chenderong Balai in the Sungei Manik area of Perak. With regard to work in the other areas it is thought that, without a radical alteration in the distribution of population and in the system of ownership, mechanical cultivation is only likely to be worth-while if it enables the agriculture in these areas to be improved so that both additional crops and an increased yield of padi can be obtained. Large-scale introduction of mechanical cultivation in such areas would entail a complete re-arrangement of the smaller subdivision of padi fields customarily found.

Sufficient progress has been made in the past two years for the programme of agronomic research to be much extended, and a start will be made in the coming season to solve the many agronomic problems which mechanical cultivation will introduce.

Wet or Dry Cultivation.

Earlier in this article mention was made of the difficulty in this country of completing cultural operations in the dry. In the peat areas the lack of a firm bottom makes it imperative that water shall not be lying on the land when cultivation is to be carried out, and the presence of an adequate system of drains will be essential. In the hard bottomed clay lands, with the *batas** which will still be required for water retention, it would undoubtedly be a matter of great difficulty to keep the land free from surface water throughout the cultivation period. The opinion has been expressed that every effort should be made to achieve the most rapid drainage system possible so that dry cultivation can be made the general rule. Some success along these lines was attained during the 1948-49 season at Pulau Gadong in Malacca where an interesting scheme of drainage was

* *batas* = small bund between padi plots.

devised and all cultivations were carried through in the dry. There is great doubt, however, whether the system could be applied with equal facility to all hard pan padi areas, and furthermore final cultivation in the wet (which is the traditional method) may be advantageous in itself. The whole question of wet or dry cultivation is one on which contrary opinions have been expressed and experiment is clearly needed. Experiments are to be laid down in the coming season to compare the growth and yield of padi on land: (1) cultivated dry and drilled, (2) cultivated dry with subsequent flooding and normal transplanting, and (3) cultivated wet with normal transplanting.

Sowing.

In Sungei Manik and in Malacca, where cultivation was carried out in the dry, drilling was the mechanical method of sowing employed in the 1948-49 season. Drilling suffers, however, from a serious disadvantage. If heavy rain falls soon after drilling and patches of ground become water-logged germination will not take place. It is obvious that this disadvantage is likely to be particularly serious in Malaya. During the last two decades methods have been developed in America of sowing on the water. This is carried out either from aircraft or from specially constructed carts. Experiments have shown that these methods result in a higher yield than that obtained by drilling and that this increased yield results from reduced weediness. It is necessary to determine whether seed broadcast on the water will germinate satisfactorily under Malayan conditions, and trials will be started in the coming season to obtain information on this point.

It has been maintained that transplanted padi will always give a higher yield than drilled padi. Experiments which are being started in the coming season should show whether this is so or not. Consideration will also be given to the possibility of mechanizing transplanting, though this is likely to prove a very difficult problem.

As far as drilling is concerned optimum seed rate and spacing are factors requiring to be determined, and experiments have been designed for this purpose for the coming season.

Methods of Cultivation.

Some mention has been made earlier in this article of the effect of cultivation on weed growth. In large areas of mechanically cultivated padi, weed growth is likely to be an extremely important factor and it is therefore very desirable to study, at an early date, the effect of different types and intensities of cultivation on weed growth as well as on yield.

In the peat areas the only really satisfactory implement has been a cut-away disc-harrow. The use of harrow-ploughs and stump jump disc-ploughs are to be investigated as soon as suitable implements can be obtained.

In the hard-pan areas the effect of the substitution of rotary cultivation for the normal ploughing and harrowing needs to be investigated.

Experiments are to be laid down to compare rotary cultivation with ploughing followed by different methods of after-cultivation.

Trials of Tractors, Wheel Types and Implements.

Several new tractors are available for trial in the coming season and new ideas on the development of track and wheel design are to be tested. It has been shown that soil variation is such that certain wheel designs and certain tractor-implement combinations may be successful in some situations though quite useless in others. It is intended, therefore, to try out as many combinations as possible in as many different situations as time and other factors will permit, and areas have been selected for this purpose.

The Opening of New Padi Areas.

If mechanical cultivation is to be undertaken on any extensive new areas it is a first essential that these areas shall be freed from stumps and submerged timber. Felling and burning of jungle areas presents no very great difficulty, but stumping is very expensive if done by hand, while mechanical stumping presents numerous problems some of which were described in an article in a previous number of this Journal(2). Investigations into methods of mechanical stumping are therefore clearly needed and consideration is now being given to a number of different methods which it is hoped to try out in due course.

References.

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(2) Allen, E. F. and Bewlay, E. W. Investigations into the Mechanical Cultivation of Wet Padi on Peat Soils in the State of Perak. *Malayan Agricultural Journal*, Vol. XXXI, January, 1948.

WET PADI MECHANICAL CULTIVATION EXPERIMENTS IN KELANTAN, SEASON 1948-1949

BY

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Introduction.

The conditions under which wet padi is grown in Kelantan are in general distinctly different from those in States on the West Coast, the characteristic features being as follows.

(1) Although Kelantan is the second largest producer of padi in Malaya with an area of approximately 168,000 acres under padi, of which 138,000 acres are under wet padi, there is no shortage of labour for planting the whole of this area annually, and there is in fact an acute land hunger. A very much larger area could be planted were suitable land available. As a result of this, individual lots of land tend to be extremely small in area (frequently under ¼ acre) while variations in the level of the ground necessitate the construction of many bunds for water control.

(2) The climate of Kelantan is markedly seasonal, and relatively hot dry weather is experienced from February to July. During this period practically all the wet padi land dries out completely, so completely in fact that if the showery weather of June does not develop, the small-holder may be quite unable to commence cultivation of his padi land, the wooden plough drawn by a pair of oxen having neither the strength nor power to penetrate the soil. This is one of the factors which cause late planting of padi, which in most cases is followed by reduced yields.

(3) The majority of the Kelantan wet padi soils have a firm bottom at the limit of the normal depth of cultivation, and during the padi season water is retained on the surface of the ground although the true water table in the ground may be at a depth of 15 ft. or more. Since no padi areas are provided with a reliable source of irrigation water at all times of year, the progress of padi planting is dependent upon rainfall.

(4) The padi fields in Kelantan cover large expanses of land, but are broken up by ridges of higher ground, usually only a few feet above the general level of the padi fields, and frequently intersected by wandering water courses. With few all-weather roads and bridges, access tends to be bad. The indigenous agricultural implements, plough, harrow, and yoke for the cattle, are however very light to carry, being made of wood, and problems of transport do not arise.

(5) In terms of production, having regard to the very large amount of labour which goes into the planting of padi, yields in Kelantan are very low, and over a period of years are unlikely to average more than about 250 gantangs (about 1,300 lbs.) per acre. With a growing population and a set limit to the amount of land available for wet padi cultivation, it is a matter of the very greatest importance to increase the output not only of padi but also of other crops, both on an acreage and capitation basis. At the same time, since there is no occupation other than fishing as an outlet for human activity, it is necessary that the existing agricultural population should remain fully employed on the land.

Results of Former Cultivation Experiments.

Low power, low speed agricultural implements, although not unsuitable for use at a time when the requirements of both food and imported goods were much smaller, may now be effectively preventing the development of agricultural production on a scale sufficient to meet the greatly increased requirements of a much larger population. With a view to determining whether the shallow ploughing done by the indigenous Kelantan plough is in itself a limit to the yield of wet padi, an experiment was laid down at Kota Bharu Experiment Station in 1935 and continued for three seasons, in which deep cultivation (digging to a depth of 1 ft. with a changkol), done shortly after harvest or shortly before planting, was superimposed over the usual method of cultivation with which it was compared. The results of the first season's work only just failed to reach significance, but the indications were that deep cultivation done with a changkol shortly before preparation of the land for padi planting had a deleterious effect on the yield of wet padi. In the second year and again in the third results were all insignificant, and there was nothing to suggest that deep cultivation done at either time of year, nor the residual effects of these treatments in subsequent years, had had any effect on the yield of padi.

In 1940-41 an experiment was laid down on the same Station to test the effect of off-season cropping of wet padi land with vegetables. The vegetable cropping programme compared vegetables grown with and without manure, and the padi crop that followed the vegetables was compared with that following an undisturbed fallow, with and without manure. The results were significant, and showed that a 45 per cent. increase in yield of padi followed off-season cropping with vegetables, and that the increase in yield was almost entirely due to the cropping with vegetables, and not to the manure. Further work on these lines was halted by the war.

Programme for 1948-49 Season.

In April 1948, a standard Fordson Major tractor on steel wheels, with trailing mould-board plough and disc-harrow was supplied, and shortly afterwards a Farmall "A" with associated implements, with which two

standard exploratory experiments, which had been recommended by the Standing Committee on Crop Investigations, were undertaken. These two standard experiments followed fairly closely in general principle the two pre-war experiments mentioned above. On account of the late delivery of the equipment, which was also suffering from certain mechanical faults, a rather late start was made with the execution of the experimental programme which shortened the interval of time which should have elapsed between the dates of cultivation.

In addition to the above medium equipment, there were also supplied a Trusty horticultural tractor and a B.M.B. Plowmate, both with associated equipment, and a Howard Gem rotary hoe. These were subjected to a critical comparative test with the Kelantan plough and harrow.

At padi harvest, early in 1949, tests were made of the Trusty Grass Cutter and Lloyds Autosickle for the mechanical cutting of padi, and a trial was made of a locally designed and constructed prototype padi thresher.

Throughout the padi season, detailed records were kept of the labour requirements (in man hours per acre) of every operation, together with rates of working and fuel consumption of the tractors.

At the outset all equipment in use was standard, but as time went on and experience was gained modifications were made to existing equipment and new implements were constructed as soon as the failings of the original machinery were known. It requires no emphasis that in the early stages no elaborate experimental lay-out and programme are desirable, since it is almost inevitable that the programme cannot be adhered to, and that purely mechanical considerations will prevent certain cultural operations from being performed, either at the particular time required or indeed at all. These remarks apply with special force to cultural operations which have to be performed under wet or sticky conditions. Within the general scope of the investigations there has had to be a considerable degree of flexibility and compromise.

Experiments with Medium Tractors.

(a) Kota Bharu Experiment Station.

Kota Bharu Experiment Station is situated on a soil type characteristic of large areas of padi land in the district, and is provided with full water control, drainage and irrigation both being excellent. These two good points are however off-set by the fact that the Station was not originally laid out with the use of mechanical equipment in mind, and it is also the principal Station for padi varietal work in the State. The amount of land available for mechanical experiments was not therefore as extensive as could be wished.

The following experiments were undertaken:—

(I) Standard Experiment "A". Depths and Time of Ploughing.

The experiment was laid down as two randomised blocks of seven

PLATE I.

Locally made toothed harrow, bogey mounted, for the Trusty tractor, which was quite a useful implement for after cultivation of wet padi at Kota Bharu Experiment Station. Here shown with the harrow lowered into the position for maximum depth of working.

PLATE II.

With standard rear wheels the Fordson tractor ploughed three furrows quite well on most parts of the Jakar experiment area. Steering was, however, still difficult.

PLATE III.

The Fordson tractor, with paddle wheels fitted front and rear, was unusable for after-cultivation of recently ploughed land at Jakar in spite of some standing water. The wheels absorbed almost all the power.

PLATE IV.

Fordson paddle wheels and locally made power-lift toothed harrow ready for testing at Jakar, Kelantan.

plots each (plot size about 2 chains x ½ chain) to test the following treatments:—

A = 8-10 ins. ploughing shortly after harvest.
B = 4 ins. „ „ „ „
C = 4 ins. „ „ before planting.
D = 8-10 ins. „ usual time.
E = 4 ins. „ „ „
F = Normal cultivation with Kelantan plough and harrow at usual time.
G = 8-10 ins. ploughing shortly before planting.

The land on which this experiment was laid down is relatively high and cannot be planted early in a normal season until irrigation water has been applied. It was therefore decided to do all the mechanical cultivation under the easiest conditions for standard tractors and implements, i.e. in the dry, and to do the cultivation of treatment F with water on the land as usual from the second ploughing onwards.

Due to the late arrival of the tractor and implements, treatments A and B, ploughing shortly after harvest, were not undertaken until 20th April, or about two months after padi harvest was completed. This work was done with a two-furrow trailing mould-board plough.

Treatments D and E were done with a three-furrow power-lift mould-board plough on 30th August, on which day treatment F was also ploughed.

During the two months which elapsed between the early ploughing and usual time ploughing of treatments A and B, a very heavy growth of off-season weeds developed which was most difficult to plough in, and it was evident that the cultivation had stimulated the germination of dry land weeds, seeds of which had been lying dormant in the soil.

The late ploughing of treatments C and G was done on 30th September.

Mechanical harrowing was done with the front gang of a Martin disc-harrow.

Irrigation water was applied a day or two before transplanting seedlings of Radin China 4 in the normal fashion on 10th October.

A standard Fordson Major tractor mounted on steel wheels was used throughout.

Water consumption on the mechanically cultivated plots did not appear to be any heavier than on the normally cultivated plots. All plots, however, tended to be short of water, as the season was a dry one and demands on the supply of irrigation water were heavy. Growth generally was no more than fair on all plots, and the only consistent difference observed was that deep ploughing initially caused yellowing of the padi, but this passed off after a few weeks and the padi became a normal green colour.

Summarised details of working times are given in Table I.

Table I.

Average Working Times.

(man hours per acre).

Operation	A	B	C	D	E	F	G
Early ploughing ..	4.0	4.0	Nil	Nil	Nil	Nil	Nil
Usual ploughing (1st) ..	5.6	3.5	Nil	4.5	3.6	23.0	Nil
Usual harrowing (1st) ..	Nil	Nil	Nil	Nil	Nil	9.0	Nil
Usual ploughing (2nd) ..	Nil	Nil	Nil	Nil	Nil	21.3	Nil
Late ploughing ..	Nil	Nil	4.0	Nil	Nil	Nil	10.3
Final harrowing ..	4.3	4.3	4.0	7.3	4.6	25.0	5.6
Total ..	13.9	11.8	8.0	11.8	8.2	78.3	15.9
Transplanting ..	52.0	52.0	43.9	43.9	52.0	39.9	53.3
Weeding ..	244.0	302.0	236.1	128.7	292.6	162.0	102.0
Cutting padi with sickle ..	36.6	35.0	35.0	33.3	31.7	33.3	36.6
Threshing padi in tong ..	45.0	53.3	66.7	51.6	53.3	53.3	55.0
Total (normal labour) ..	377.6	442.3	381.7	257.5	429.6	288.5	246.9

In assessing the relative importance of the working times in Table I, it should be remembered that the plot size is so small that the tractor is working under extremely unfavourable conditions, but that the Kelantan plough and harrow are working under average conditions.

There is a clear connexion between dates and depths of ploughing and the incidence of weeds as judged by the length of time required to pull them up by hand, a criterion which was considered preferable to the actual weight of weeds. Comparing shallow depths of ploughing (treatments B, C, and E) with deep ploughing (treatments A, D, and G) it is evident that deep ploughing gave better weed control than shallow ploughing (approximately 158 man hours per acre as against 277 man hours per acre). Times of cultivation, early (A, B), usual (D, E), and late (C, G) give decreasing weeding times in the above order (approximately 273, 210, and 169 man hours per acre). The normal Kelantan method of cultivation gives an equivalent figure of 162 man hours per acre, which suggests that as the latter is conducted at the usual time of year mechanical methods of cultivation used in the experiment were not at all well chosen to effect weed control. Furthermore, although the Kelantan plough only ploughs to a depth of about 4 ins., weed control was quite as good as that associated with the deepest mechanical ploughing. No data were obtained from this experiment which might suggest the reason for this, but a possible explanation is forthcoming from the results of the trial of horticultural machines, to which reference is made in a later paragraph.

Summaries of harvest yields are given in Tables II and III.

Table II.

Yields.

(in lbs. per plot of 1/20th acre)

	A	B	C	D	E	F	G
Block I ..	173.5	107.0	70.0	109.3	143.0	183.8	104.8
Block II ..	128.3	74.0	100.3	112.5	112.0	150.5	148.3
Mean Yield	150.9	90.5	85.1	110.9	127.5	167.1	126.6

Table III.

Mean Yields by Times and Depths of Cultivation.

(in lbs. per plot of 1/20th acre)

Depth		Early (A, B)	Normal (D, E)	Late (C, G)	Mean
Deep (A, D, G)	..	150.9	110.9	126.5	129.4
Shallow (B, C, E)	..	90.5	127.5	85.1	101.0
Control (F)	..	—	167.1	—	—

This experiment has shown that the methods of mechanical cultivation adopted have not in the first season increased wet padi yields, and that there are grounds for suspecting that some factor inversely related to the depth of ploughing has depressed the yields.

(II) Standard Experiment "B". Depths of After-harvest Ploughing, and Off-season Cropping.

This experiment was laid down as three randomised blocks of two main plots each; each main plot was divided into four sub-plots. The size of the main plots was about 2 chains x ½ chain, which although still very small was the largest that could be accommodated on the Station.

Main plot treatments were:—

A = 8-10 ins. ploughing shortly after harvest.
B = 4 ins. " " " "

Sub-plot treatments superimposed on the above were:—

P = natural grass or weed growth.
Q = green manure.
R = bare fallow (kept cultivated).
S = short bare fallow followed by short term crop.

The land under this experiment adjoined that under Standard Experiment "A", but was at a slightly lower level, and after-harvest ploughing was done on the same day, 20th April, with the same Fordson tractor and trailing mould-board plough. Owing to the small size of the sub-plots no further cultivation was possible with the Fordson, and the work was undertaken with horticultural machines. Sub-plots Q and S were broken down with the Trusty tractor and its Cambridge roll and disc-harrow. The choice of a green manure and short term crop presented a difficulty, and the selection of green gram for the green manure and dwarf cowpea for the crop was not a very happy one. Irrigation was necessary before either germinated. The green manure grew rapidly in the early stages, but was suddenly and almost entirely destroyed by night-flying beetles. The dwarf cowpea was well suited to the newly ploughed land, and after harvesting the crop there was more plant residue to turn into the soil than there was from the green manure plots.

Off-season growth on sub-plots P was not at all heavy, and a bare fallow was maintained on sub-plots R by a single cultivation with the Howard Gem Rotary Hoe performed about two months after the post-harvest ploughing.

The preparation of the land for padi planting was done with the Fordson tractor and three-furrow power-lift plough, and disc-harrowed once in the dry with the front gang of the Martin disc-harrow. Irrigation water was run on the land shortly before seedlings of Radin China 4 were transplanted by hand.

Water consumption during the padi season did not differ visibly between deep and shallow ploughed plots, and appeared to be quite normal, even though the land had been worked in the dry and had not been puddled.

Visible differences between treatments were very small and probably meaningless, although for a period of a few weeks treatment R was perceptibly better than the remainder. The incidence of weeds as estimated by eye was in good agreement with the labour requirements for weeding.

Summarised details of working times are given in Table IV.

Table IV.

Working Times. Cultivation by Tractor.

Operation	hours per acre A	B
Ploughing after harvest ..	4.0	4.0
Ploughing for padi ..	5.2	2.4
Disc-harrowing ..	3.3	3.3
	12.5	9.7

Working Times. Manual Labour.

Operation	man hours per acre							
Transplanting ..	50.7				54.2			
Weeding ..	52.9				103.3			
	P	Q	R	S	P	Q	R	S
	74.7	78.3	17.7	40.9	190.0	138.7	46.3	39.0

Deep ploughing has once again given better weed control than shallow ploughing, although the deeper ploughing took rather longer to do with the three-furrow power-lift plough. The small increase in width of working brought about by the third mould-board required the tractor to be operated in a lower gear.

The labour requirements for weeding the sub-treatment plots follow expectations, though Q plots are perhaps higher than they would have been had green gram not failed so badly as a green manure.

Padi yields from all the treatments were very uniform, and there are clearly no significant differences between them. Table V gives a summary of mean yields in lbs. per plot of 1/80th acre.

Table V.

Mean Yields.

(in lbs. per plot of 1/80th acre)

	P	Q	R	S	Mean
A. (Deep ploughed) ..	23.1	24.1	26.9	25.4	24.9
B. (Shallow ploughed) ..	24.1	22.5	23.9	21.8	23.1

(b) Experiments on Small-holders' Land.

Two sites were selected on small-holders' land on different soil types to provide further information on Standard Experiment A, and to test out more or less standard wheeled tractors and implements under a wider range of conditions.

(I) Salor.

The site chosen was on rather low-lying fairly heavy clay, not irrigated but well supplied with water and fairly easily drained. As at Kota Bharu Experiment Station there was a firm bottom to the land. Sufficient land was available for two randomised blocks as in Standard Experiment A, the plot size being about 2 x ½ chain.

Ploughing of treatments A and B, actually to be done soon after harvest, was not commenced until June, when it was done without difficulty by the Farmall A tractor and two-disc trailing plough, the tractor being fitted with locally-made steel wheels.

The ploughing of treatments D and E and second ploughing of A and B was done by the Fordson tractor with standard steel wheels and three-furrow power-lift plough on 14th September, followed by cattle ploughing and harrowing of treatment F on 16th September. By this time there was quite a lot of water on the land.

Late ploughing of treatments C and G was done on 27th September, on which day harrowing of the other plots was started. The second ploughing and harrowing of treatment F was done on 28th September, and transplanting on 3rd and 4th October, using Padang Trengganu padi.

Ploughing of this land presented no difficulty at all, but no implement was available which would harrow efficiently or provide a substitute for harrowing. The front gang of a disc-harrow was tried at first, but it soon sank into the mud, clogged up, and ultimately caused bogging down of the tractor. A locally-made wooden-framed toothed harrow was also tried, but while it did some levelling it was none the less a most inefficient implement, and the wheels of the tractor did most of the after-cultivation.

During the growing season of the padi it was clear that deep cultivation caused yellowing of the padi to develop within ten days or so of transplanting, and was accompanied by poor growth for a period of two to three months. Tillering appeared to be delayed. On the plots which had been deeply cultivated mechanically, the best growth was to be found close to the bunds where the least cultivation had been done. Maturation of padi growing on deeply cultivated plots was delayed, and ripening was uneven probably on account of late formed tillers which were, however, not too late to develop normal ears. This lengthening of the maturation period and uneven ripening of the padi were not peculiar to this experiment alone, and have been a general feature of all deep cultivated plots of both wet and dry padi.

Weeds were not troublesome, and although there was some Fimbristylis growing in all plots the quantity was insufficient to warrant weeding.

Summarised details of working times and yields are given in Tables VI, VII and VIII.

Table VI.

Average Working Times.

(man or tractor hours per acre)

Operation	A	B	C	D	E	F	G
Early ploughing ..	5.3	6.8	—	—	—	—	—
Usual ploughing (first) ..	3.2	3.3	—	3.6	2.9	16.4	—
Usual harrowing (first) ..	—	—	—	—	—	16.6	—
Usual ploughing (second) ..	—	—	—	—	—	18.7	—
Late ploughing ..	—	—	3.6	—	—	—	2.7
Final harrowing ..	3.9	3.2	2.9	4.2	2.8	18.7	2.8
Total ..	12.4	13.3	6.5	7.8	5.7	70.4	5.5
Transplanting (overall average)	89.0	89.0	89.0	89.0	89.0	89.0	89.0
Cutting padi with sickle ..	22.5	22.5	20.1	24.9	20.1	30.0	20.1
Hand threshing (with tong) ..	37.5	35.1	35.1	27.6	40.0	35.1	37.5
Total (normal labour) ..	149.0	146.6	144.2	141.5	149.1	154.1	146.6

Table VII.

Yields of Padi.

(in lbs. per lot of 1/30th acre)

	A	B	C	D	E	F	G
Block I ..	59.5	30.3	48.0	45.0	49.0	48.3	46.5
Block II ..	59.3	64.5	45.3	59.5	57.0	54.3	52.0
Mean yield ..	59.4	47.4	46.6	52.2	53.0	51.3	49.2

Table VIII.

Mean Yields by Times and Depths of Cultivation.

(in lbs. per plot of 1/30th acre)

Depth	Early (A, D, G)	Normal (D, E)	Late (C, G)	Mean
Deep (A, D, G) ..	59.4	52.2	49.2	53.6
Shallow (B, C, E) ..	47.4	53.0	46.6	49.0
Control (F) ..	—	51.0	—	—

While these figures show a fairly consistent and not unreasonable trend, they are statistically insignificant.

(II) JAKAR.

An area was selected on medium clay mixed with coarse sand, the sand content being sufficiently high to render the soil rather friable, and the bottom to the land should therefore be described as distinctly soft. Under wet conditions this land afforded a poor grip for standard Fordson steel wheels, and the usual time ploughing of treatments D and E was done under great difficulty on 12th September, with frequent stoppages owing to bogging-down of the tractor. On 21st October a great effort was made to do the late ploughing of treatments C and G, as well as harrowing of all plots, but it met with complete failure. Paddle wheels obtained from Province Wellesley were tried and found to be rather worse than the standard Fordson wheels. The Trusty horticultural tractor was also put into the area, and it succeeded in cultivating some of the higher ground, but could not get through the deeper spots. The experiment was then abandoned.

Trial of Horticultural Machines.

An experiment was laid down at Kota Bharu Experiment Station to assess the suitability of horticultural machines for wet padi cultivation, and their effect upon yield compared with the normal method of cattle cultivation with the Kelantan plough and harrow. The lay-out adopted was six randomised blocks of four plots each for comparison of the following equipment:—

A = Kelantan plough and harrow (control).
B = B.M.B. Plowmate tractor, and associated equipment.
C = Howard Gem Rotary Hoe.
D = Trusty tractor and associated equipment.

The site of the experiment was ideal, the land having a hard bottom, and drainage and irrigation water could be fully controlled. Fairly skilled operators were also available.

The first ploughing was carried out while the soil was only moist, and all the machines performed reasonably well. Disc-harrowing with the B.M.B. was difficult, as the soil was by then becoming sticky and clogging the disc, and the rubber-tyred wheels were only moderately effective although

better than the locally made steel wheels. The Trusty also had difficulty in disc-harrowing the sticky soil, and a locally-made toothed harrow was substituted for the disc-harrow. By the time the second ploughing was due, there was water lying underneath the furrow slices, and irrigation water had to be added to enable the B.M.B. to get through at all, even on its steel wheels, and it proved to be an exhausting operation for several men. The Trusty on its standard steel wheels performed well, while the Rotary Hoe with paddle wheels was satisfactory after further water had been applied to the land, although turning was a heavy job for two men. For the second harrowing, all plots were flooded to a depth of 4 ins. or more. Neither the B.M.B. nor Trusty disc-harrows could be used, as they penetrated deeply into mud and built up a wall of mud in front. The B.M.B. plots had to be harrowed with cattle and a Kelantan harrow, but the Trusty put up an astonishing performance with a locally-constructed tined harrow attached to the rear of the standard bogey, and on its four wheels was capable of getting through the deepest mud.

This trial very quickly showed up the deficiencies of the equipment, especially as regards manoeuvrability of the machines and wheel design, and drew attention to the lack of an implement to use immediately after ploughing. The Trusty, with a positive drive to one only or both wheels (but unfortunately without a reverse), was incomparably better than the B.M.B. which, though having a reverse, was uncontrollable in a forward direction even with the aid of the independently operated hand brakes. The Rotary Hoe, having no steering aid other than a differential which operates when the rotor drive is disengaged, was also very difficult to manoeuvre. With regard to wheels the standard Trusty wheel with alternate lugs performed well, but locally-made steel wheels for the B.M.B., with a rather wide lattice work rim and transverse strakes, were totally unsuitable, whilst a somewhat similar type in use on the Rotary Hoe was very unsatisfactory. The failure to harrow newly ploughed sticky land, with or without added irrigation water, was not unexpected, and enough time remained to enable the special toothed harrow for the Trusty to be constructed and put into operation, but the general design of the B.M.B. did not allow of any modification to be quickly carried out. A Cambridge roll which formed part of the Trusty's equipment was tried out after ploughing, but it, too, either clogged up or sank in the mud.

In their present form, it cannot be said that any of the machines and their standard equipment are well suited to wet padi cultivation. All were comparatively expensive to run, and with the exception of the Trusty required a disproportionate amount of heavy manual labour to operate. Although the rate of ploughing can be slightly in excess of that for cattle, it is too exhausting an undertaking for a man working for the whole day in mud. Unless a relay of operators is available this will effectively prevent machines such as these being used to the limit of their capabilities. Moreover, small engines operating under difficult conditions are more prone to

stoppages from minor mechanical faults than are larger ones, nor do they require less frequent or less skilled servicing. There are many grounds for thinking that the small horticultural type of tractor, of which some are capable of good and efficient work on dry land, is not likely to be of much value to the small-holder for wet padi cultivation.

Summarised details of working times and yields are given in Tables IX and X.

Table IX.

Average Working Times.

(man or tractor hours per acre)

	A	B	C	D
First ploughing ..	14.4	12.5	19.0	16.6
First harrowing ..	8.6	6.7	—	6.3
Second ploughing ..	14.7	19.5	9.3	7.7
Final harrowing and levelling ..	23.0	12.9*	6.6	13.1
Total ..	60.7	—	34.9	43.7
Transplanting ..	40.4	45.3	43.5	47.5
Weeding ..	180.6	42.7	145.7	122.6
Cutting padi with sickle	42.7	33.3	29.4	36.3
Hand threshing (with tong) ..	52.8	55.5	49.0	52.2
Total (normal labour)	316.5	176.8	267.6	258.6

* Final harrowing of treatment B was done with a Kelantan harrow.

Table X.

Mean Yields of Padi.

(in lbs. per plot of 1/20th acre)

A	B	C	D
119.9	125.4	116.2	133.7

A peculiar feature of this experiment has been the small amount of weed growth on plots cultivated by the B.M.B. and on which the final harrowing was done with the Kelantan harrow. There appeared, at the time, to be little difference between the ploughing of the Trusty (D) and the B.M.B. (B), both of which were ploughing to a greater depth than the Kelantan plough and giving good inversion of the furrow. It is suggestive that weed control may have been improved by the use of the Kelantan harrow following first class ploughing. The locally made toothed harrow for the Trusty tended to bring weeds, and no doubt soil and seeds, to the surface where they would be more likely to develop, and the same is certainly true of the Rotary Hoe, the use of which, in a multiplication plot, caused a very heavy growth of Fimbristylis to develop. The heavy weed growth on the Kelantan plough and harrow plots (A) is however inconsistent with

the findings from Standard Experiment A at Kota Bharu Experiment Station where the customary method of cultivation gave weed control as good as the deepest mechanical cultivation.

The effect of mechanical cultivation on the yield of padi has been negligible. At no time during the growing season were there any consistent visible differences between treatments except as regards weeds, and water consumption on all plots was normal.

Experiments on Harvesting of Padi.

The Kelantan small-holder normally harvests all padi with the *ketaman* (a small knife held in the palm of the hand) the straw being cut through at a point a short distance below the ear. The operation is one usually assigned to the female members of the family, for whom it provides a light and sociable occupation. Although the output is low there are some compensations, viz. that the minimum amount of equipment is required; unevenly ripened or mixed padi can be harvested separately; and the minimum weight of crop has to be handled or carried. The ears of the padi so cut and carried off the field are either stored in that form, or threshed immediately by working with the feet (*irek*) on a raised platform.

A method of comparatively late introduction to Kelantan, and one that is not yet widely used, is that in which the straw is cut off close to the ground with a sickle and threshed out in the field by beating it on a ladder in a wooden box. The points mentioned in the paragraph above all work to the disadvantage of this method, which gains slightly in speed.

Since there are areas in Malaya where labour for padi harvesting is scarce, trials were made in Kelantan with simple mechanical equipment to see whether any of it was suitable for operation in the padi fields.

Trials of Grass Mowers for Padi Harvesting.

The manufacturers of the Trusty tractor supply, as an extra, a 40 inch cutter bar independently driven by a small auxiliary engine which can be mounted on the tractor bogey. Intended as a grass mower, it is equipped with a swath board. This machine was tried out on dry padi land, in a field of about 1 acre in area which was carrying a light crop. The system of mounting the cutter bar to the bogey was not found to be satisfactory, since it was not possible to raise the engine and cutter bar sufficiently in the travelling position to keep them clear of the ground, and in the highest position when working the cut was too low for padi. In addition, the mounting of the auxiliary engine in front of the bogey wheel gave the tractor a very restricted turning circle in a clockwise direction (which is the direction of travel in a field, the cutter bar being mounted on the right-hand side of the bogey). This also meant that the engine rise over it. Vibration of the auxiliary motor and cutter bar was probably increased by the type of mounting, and although the speed of the engine would strike any obstruction before the bogey wheel could reach it and

was reduced as far as possible, consistent with proper cutting, screwed components shook loose in a very short time. The clutch failed at very frequent intervals due to shearing of the clutch pins, and this was not cured until the clutch was altered to take six pins and springs instead of the three originally provided.

In the test it was found possible to get good, clean cutting up to a speed of about 4 miles per hour, equivalent to upwards of 1½ acres per hour if no time was wasted in turning, but in practice about ½ acre an hour when working in a 1 acre field would be a good result. The major difficulties arose after the padi had been cut, as it was rarely, if ever, laid in a neat swath, the individual straws being liable to fall forwards or sideways according to the way they stood in the first place or according to the breeze. Under the most favourable conditions, the padi cut near the fixed end of the cutter bar fell straight back on to the ground, and that cut nearer the tip of the cutter bar was turned over this more or less at right-angles by the swath board. A good deal of time was spent trying to overcome this, but no success was met with, and the cut padi was always very difficult to pick up so that the ears should be close together, the condition necessary for effective hand-threshing. Even when cutting a heavy crop, there was no real improvement in the way the cut padi lay.

All cut padi lying on the ground had to be picked up and carried a few feet to clear a track for the next trip round of the tractor, without which the padi was further deranged and losses were incurred through the tractor wheels breaking up the ears. To keep pace with the rate of cutting, it was found necessary to employ for this purpose about 16 men, equivalent to 32 man hours per acre. Since 32 man hours is sufficient for cutting padi with a sickle and leaving the cut padi in neatly arranged bundles, there is clearly no object in cutting padi with a grass mower so long as threshing is dependent upon the padi ears being substantially all together in the sheaves.

The second machine to be tested was the Lloyds Autosickle, a light two-wheeled self-propelled machine with the cutter bar mounted at the front. This machine had a good cross-country performance and was reasonably manoeuvrable in confined spaces. It had one defect in common with the Trusty, namely that the cut padi fell in all directions, especially in front of the machine. No very extended tests were made with it since, without considerable modification, it appeared to be unsuited to the purpose.

The conclusions reached are that small grass cutting machines are not at all promising for use in harvesting padi, and that mechanical cutting alone is not likely to effect much, if any, saving in time. Even if a thresher were available which would efficiently thresh a jumble of straw and ears, no small-holder would wish to carry off the field a large quantity of straw and ears for threshing later, nor could this be left lying on the field for long. Given threshing facilities, a header could be of some use

provided it were exceptionally manoeuvrable, for, once cut, it seems bad practice to allow padi to fall on to the ground.

Trial of Mechanical Padi Thresher.

The usual method of threshing padi on Experiment Stations in Kelantan has been by beating the padi on a ladder in a wooden box after cutting with a sickle, and it was felt that this method was capable of considerable improvement if for no other reason than that it requires a degree of physical effort which can doubtfully be maintained throughout the working day.

On account of the need for easy transportation, no elaborate machine was thought desirable in the first instance, especially as no information was available regarding the principles of threshing padi mechanically. Preliminary trials were made with a small scale model, after which a full size machine was made. This consisted of a steel drum about 15 ins. in diameter and 3 ft. 6 ins. in length mounted on a spindle. Three feet of its length was covered with stout wire staples, each about 1¼ ins. in width and height, welded to the drum in rows 2½ ins. between centres, each staple spaced at 1 in. in the row. The staples were set at a very slight angle to the direction of rotation of the drum. A belt drive was taken from the last six ins. of the drum to the power take-off of the Farmall A tractor, and the sides and rear of the threshing drum were provided with screens to collect the grains of padi. The drum was wide enough to allow two men to work on it simultaneously, each holding a sheaf of padi, whilst a third man was picking up a sheaf of padi from the heap nearby.

This very simple thresher fulfilled certain of the conditions found necessary for padi, which requires rather gentle handling if the ears are not to be broken up into short lengths with the grain still adhering. The staples effected a thorough combing of the sheaves of padi and stripped the grain off cleanly, although it was necessary to turn the sheaf over to make sure that all the ears had been threshed out. With too high a drum speed, or over-ripe padi, there was trouble from breakage of the ears, but with an appropriate drum speed there was no more breakage of ears than is ordinarily experienced with the tong. This method of threshing, however, did not speed up the rate of threshing, and though all the labourers employed on the job found it easy work, the output per man was practically the same as for tong threshing, with running costs of the tractor to be added, of which fuel consumption amounted to 4 pints of T.V.O. (tractor vaporising oil) per hour.

There were marked differences between the rates of threshing for different varieties of padi, Seraup Besar types and Siam types being quick and easy to thresh, whilst Padang Trengganu types were slow and difficult.

With regard to the threshing rate, improvements could be made in the organization of the labour to ensure that the drum is in full use all the time, which was not the case during the trials, although the same

criticism could be made of the other threshing methods. Both beating padi in a tong, and power threshing with the drum suffer from operators having to be careful when picking up the padi to ensure that the ears are properly arranged in the sheaf for clean threshing, and this limitation appears chiefly to determine the output per hour. It is suggested that probably no great increase in speed of threshing can be achieved until a threshing device is available which will deal with relatively unsorted or unarranged padi. Clearly the method of cutting the padi in the field is linked with the method of threshing, and there is no object in rapid mechanical cutting of padi in the field if the product is unthreshable, nor is there much point in having a quick method of threshing which works only if the sheaves of padi are in a condition which is unobtainable in practice.

Tables XI and XII give an indication of the efficiency of the various methods. Harvesting and threshing rates for dry padi are especially low as crops are usually thin and uneven, and threshing of the smaller ears is additionally more difficult.

Table XI.

Dry Padi Harvesting Operations.

(output per man hour in lbs. of padi grain)

Operation	Maximum	Minimum	Average
	lbs.	lbs.	lbs.
Cutting with *ketaman** ..	6.4	0.2	2.9
Cutting with sickle† ..	23.1	3.7	13.1
*Irek** ..	89.6	1.2	41.5
Threshing with tong* ..	39.5	6.3	19.6

* Rates determined from 90 plots.
† „ „ „ 88 „

Table XII.

Wet Padi Harvesting Operations.

(output per man hour in lbs. of padi grain)

Operation	Maximum	Minimum	Average
	lbs.	lbs.	lbs.
Cutting with sickle* ..	122.5	35.0	72.1
	176.8	46.8	103.8
	100.6	28.1	73.2
Threshing with tong* ..	74.3	23.1	47.7
	75.2	26.5	45.1
	74.7	28.1	48.8
Mechanical threshing drum† ..	64.0	25.8	45.6

* Rates determined from experiments 12, 13 and 22. (62 plots).
† „ „ „ 25 hours working. (6 fields).

Summary.

1. It has been found possible to use medium size tractors, such as the Fordson Major, on standard steel wheels in wet padi land which has a hard bottom not more than 12 ins. below the surface of the ground.

2. A three mould-board power-lift plough was found convenient in use and capable of a reasonable standard of work under water.

3. No implement was available for use with medium tractors which would harrow efficiently, or provide a substitute for harrowing, in mud and water. There is little doubt that such an implement when obtained should be fitted to the power-lift.

4. No evidence was obtained to suggest that deeper ploughing was likely to increase padi yields, but there was a fairly clear connexion between depths and times of ploughing and incidence of weeds.

5. Land cultivated wholly in the dry, and irrigated shortly before transplanting, grew a normal crop, with no apparent increase in water consumption.

6. Off-season cropping treatments affected weed growth, but had no significant effect upon padi yields.

7. Horticultural machines varied greatly in their performance in the mud and water, but none seems likely to replace animal draught. Their use had a negligible effect upon padi yields, but gave some information on the problem of weed control.

8. A trial of two grass mowers for cutting padi gave unpromising results.

9. Data are given on labour requirements at harvest, and details of construction and trials of a simple power-driven thresher are described.

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DRY PADI MECHANICAL CULTIVATION EXPERIMENTS, KELANTAN, SEASON 1948-1949

BY

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Introduction.

About 25,000 acres are cultivated annually with padi *tugalan* (dibbled) in Kelantan, the land used for the purpose being very similar to that used for wet padi, but lying at a slightly higher level. It occasionally happens in an abnormally wet season that some of this acreage may be planted with a short term wet padi, but as a general rule dry padi land is quite distinct. Most, if not all, of this dry padi land would be capable of raising crops of wet padi were irrigation available, with increased yields of at least 100 per cent. The future of dry padi cultivation in Kelantan therefore depends upon whether or not it is possible to provide effective irrigation.

The size of individual lots of dry padi land is usually greater than that of wet padi, and not infrequently may be 1 acre or more, the occasional bunds serving primarily as a boundary line, and indirectly as a control of soil erosion.

Although manuring is usually practised, soil fertility and crop yields are low. Labour requirements are very high, and the success of the operations is highly dependent upon weather conditions over a period of some 3 months preceding and succeeding planting. It is a difficult and risky crop to raise, with small reward for the work that goes into its cultivation. On the other hand the labour demand does not clash with that for the wet padi, and a poor wet padi season is often a good season for dry padi.

The principles of dry padi cultivation are simple, but not easy of realisation. Ploughing of the fallow land is started as soon as the wooden plough can penetrate the ground after the end of April, and ploughing and harrowing should be continued at intervals until the middle of July, the operations being directed towards the preparation of a deep friable seedbed and the killing off of all weeds. Under no circumstances should the land be worked when it is liable to poach. Planting of the seed should be completed not later than the first week in August so that in a normal season one or two weedings can be undertaken before the onset of the heavier rain. Dry padi does not tolerate muddy ground, or standing water, until a late phase in its development, and in the early stages it is disastrous.

Results of Former Cultivation Experiments.

Dry padi cultivation experiments were commenced in Kelantan at Kota Bharu Experiment Station in the 1934-35 season, and continued for

4 years. Highly significant increases in yield followed deep cultivation, done to a depth of about 1 ft. with a changkol, the increase in yield usually ranging from 50 to 100 per cent. Significant residual effects lasted for about 2 years. The highest yields were usually associated with deep cultivation done shortly after harvest, although the same cultivation done later in the season did not give significantly lower yields. At that time there were no means of doing deep cultivation at an economic cost; the results from the experiments could not be put into practice, and they served merely to confirm the belief that the thorough cultivation of small areas of dry padi land for vegetable growing in the off-season did indeed improve the condition of the soil for the next crop of padi.

Growth of padi on deep cultivation experimental plots was always abnormal in the early stages, germination often being poor, with a high seedling mortality, and for a period of some weeks the padi was stunted and a very poor colour, but after three months the situation would change and the padi on deep cultivated plots would quickly out-strip the other.

Programme for the 1948-49 Season.

The conditions under which dry padi is grown are so similar to those for cereal crops in temperate countries, for which mechanical equipment has been designed, that it was felt that in spite of the uncertainty attached to the long term outlook for dry padi cultivation in Kelantan, investigations into the mechanical cultivation of dry padi were fully justified.

Melor Experiment Station, covering an area of about 40 acres of dry padi land, was admirably suited for mechanization, and it was possible to lay down experiments with a sufficient number of replications to make the results statistically reliable.

The programme generally followed the lines of the wet padi programme, with an experiment on the depths and times of cultivation; an experiment on depths of cultivation and off-season cropping; an experiment to provide a comparison of horticultural implements with the Kelantan plough and harrow; and an experiment on the planting of padi with a seed drill.

The equipment consisted of one Fordson Major tractor mounted on steel wheels with a trailing mould-board plough and disc-harrow, and a Farmall A tractor with disc-plough and disc-harrow. A Mitchell seed drill was used for the drill trials.

Horticultural implements tested were the Trusty tractor and associated implements; the B.M.B. Plowmate tractor with associated implements; and a Howard Gem rotary hoe.

On account of the late arrival of the equipment and certain mechanical troubles, the times of cultivation could not be adhered to, and all time intervals had practically to be disregarded. In addition it was far too late in the season to attempt to plant off-season crops and green manures, so that the experiment on off-season cropping resolved itself into one on deep and shallow ploughing; it will not be until the 1949-50 season that this

Table I.

Dates of Cultivation.

Cultivation	Treatment						
	A	B	C	D	E	F	G
Early ploughing ..	May 8-9	May 8-9	—	—	—	—	—
Normal ploughing ..	—	—	—	May 15-16	May 15-17	May 18-24	—
Late ploughing ..	—	—	May 18	—	—	—	May 17
1st mechanical harrowing ..	June 16-20	June 16-20	June 16-17	June 16-20	June 16-20	—	June 16-17
2nd ploughing ..	June 26-27	June 26-27	July 11-18	July 10-11	July 10-11	June 15-16	July 18
1st control harrowing ..	—	—	—	—	—	June 16	—
2nd mechanical harrowing ..	July 26-27	July 26-27	July 26-27	July 26-27	July 27	—	July 27
3rd ploughing ..	—	—	—	—	—	July 7	—
2nd control harrowing ..	—	—	—	—	—	July 10	—
4th ploughing ..	—	—	—	—	—	July 26	—
Final harrowing ..	July 27-29	July 27-28	July 27-28	July 27-28	July 28-29	July 27	July 28-29
Planting ..	July 28-29	July 28-29	July 28-29	July 28-29	July 28-29	July 28-29	July 28-29

experiment will be laid down in full detail as planned. Wet weather and further mechanical break-downs delayed the seed drill experiment slightly and it was done under extremely poor weather conditions, further delay being impossible since the sole remaining tractor was urgently required for the wet padi experiments.

Experiments with Medium Tractors.

TIMES AND DEPTHS OF CULTIVATION.

This experiment was laid down as 4 randomised blocks of 7 plots each, the plot size being about 3½ chains x ½ chain, to test the following treatments:—

A = 8-10 ins. ploughing after harvest (late February—early March).
B = 4 ins. „ „ „ „
C = 4 ins. „ later than normal (late May—early June).
D = 8-10 ins. „ at usual time (late April—early May).
E = 4 ins. „ „ „ „
F = Kelantan plough and harrow, usual time (control).
G = 8-10 ins. ploughing later than normal (late May—early June).

For the reasons already given, the times of cultivation could not be adhered to, and the actual dates are given in Table I. There was a very small time interval between early, normal, and late first ploughings, but the intervals were lengthened somewhat for the second ploughings.

Mechanically cultivated plots were ploughed twice with 2-furrow mould-board ploughs and harrowed three times with medium disc-harrows. The additional amount of cultivation done on the control plots was not above that which is customary for the method, and it was also judged to be necessary to bring the land into a sufficiently clean condition for planting.

In an attempt to assess the condition of the soil at planting time, penetration tests were made with a rod inserted in the ground until it met with firm resistance, ten points being selected at random in each plot. These tests were repeated at weeding time 5 weeks later. Mean depths for each treatment (in inches) are given in Table II.

Table II.

Mean Depths for Treatments.

(in inches)

	A	B	C	D	E	F	G
At planting ..	7.3	5.8	5.8	7.2	6.0	5.2	7.3
At weeding ..	6.2	5.5	5.1	6.1	5.4	4.8	5.8
Shrinkage ..	1.1	0.3	0.7	1.1	0.6	0.4	1.5

There is an obvious connexion between depths of ploughing and the dates of the second ploughing and the amount of consolidation which took

place after planting. This consolidation of the land continued in all probability until the onset of the heavy rains, since at harvest time it was very noticeable that the padi plants on the more deeply cultivated plots were standing up distinctly proud of the surface of the ground, with a number of their roots exposed. As young dry padi is so intolerant of hard or waterlogged ground, the very open seed-bed may be more of an advantage than a disadvantage. With regard to the low penetration figures for the deep ploughed plots as compared with the shallow, it is suggested that the true depth of the cultivation has been masked by the high resistance of unbroken furrow slices which were below the reach of a medium disc-harrow, and that the apparent depth of the shallow ploughed plots has been enhanced by building up a 'fluffy' seed-bed, the depth of ploughing being within the reach of the disc-harrow.

Throughout August and September there were no consistent visible differences between treatments, but in October the deeper cultivation began to show up by improved growth and the development of an intense green colour. The appearance was estimated with a scoring card, points being given for evenness of height, colour, and weed control. Treatment means for marks allotted in October and December are given below:—

	A	B	C	D	E	F	G
October ..	20.0	17.0	15.2	18.2	15.7	13.0	20.0
December ..	16.0	14.7	12.2	15.0	12.7	10.5	15.5

On colour alone, it was evident that all the plots were perceptibly better than the general average on the Station, and, on searching for a reason, it was found that the whole of the area under the experiment, with the exception of plots A, E, F, and G of block IV, had been deeply ploughed with a steel plough drawn by a weapon-carrier shortly after the conclusion of the war; there is little doubt that this had had very considerable residual effects, although the setting of the plough for the shallow ploughing may have erred on the generous side, which may also explain the rather high penetration figures for treatments B, C, and E in the earlier table. It can hardly be ascribed to the disc-harrowing increasing the effective depth of cultivation in view of the results obtained from the second cultivation experiment which will be described later, and the relatively high yields from the control plots.

Table III gives a summary of treatment means for the times taken in tractor or man hours per acre for the various cultural operations.

The two additional ploughings done by the Kelantan plough in treatment F have not in fact reduced the amount of weeding which had to be done after planting. Deep ploughing done at the usual time or later than normal appears to be tending to increase seedling failure.

Table III.

Average Treatment Working Times.

(in tractor or man hours per acre)

Cultivation	Treatment						
	A	B	C	D	E	F	G
Early ploughing ..	4.4	4.3	—	—	—	—	—
Normal ploughing ..	—	—	—	5.0	4.3	16.6	—
Late ploughing ..	—	—	2.7	—	—	—	4.0
1st mechanical harrowing ..	0.9	0.8	0.8	0.9	1.0	—	0.8
2nd ploughing ..	2.5	1.6	1.4	2.1	1.7	13.4	2.0
1st control harrowing ..	—	—	—	—	—	2.6	—
2nd mechanical harrowing ..	0.7	0.8	0.7	0.8	0.8	—	0.6
3rd ploughing ..	—	—	—	—	—	10.1	—
2nd control harrowing ..	—	—	—	—	—	4.2	—
4th ploughing ..	—	—	—	—	—	8.9	—
Final harrowing ..	0.8	0.8	0.8	0.8	0.8	3.1	0.8
Total ..	9.3	8.3	6.4	9.6	8.6	58.9	8.2
Planting (hand) ..	28.0	28.8	31.4	30.4	28.5	27.4	28.8
1st weeding ..	85.9	87.1	83.0	97.7	85.0	91.0	76.4
2nd weeding ..	—	—	—	—	—	—	—
Supplying ..	41.3	41.7	40.8	56.6	43.4	43.3	64.8
Total ..	155.2	157.6	155.2	184.7	156.9	161.7	170.0
Cutting (sickle) ..	55.8	38.5	51.8	42.4	44.9	43.4	54.4
Threshing (tong) ..	32.0	33.6	31.6	31.3	28.9	35.0	34.3
Total ..	87.8	72.1	83.4	73.7	73.8	78.4	88.7

The amount of hand work which follows completion of preparation of the land is disproportionately high, and should be capable of substantial reduction.

Under the conditions of the experiment, the local method of dry padi planting required 300 man hours work per acre.

Table IV shows mean yields of padi, in lbs. per plot of ⅛th acre.

Table IV.

Mean Yields of Padi.

(in lbs. per plot of ⅛th acre)

Treatment	Time of Cultivation		
	Early (A, B)	Normal (D, E)	Late (C, G)
Deep (A, D, G) ..	99.2	92.6	104.0
Shallow (B, C, E) ..	104.8	87.9	88.2
Control ..	—	82.9	

In view of the small time differences, and the suspected residual effects of the deep ploughing in 1946, these yield figures should not be regarded as being typical.

Depth of Cultivation and Off-season Cropping.

This experiment was laid down as 8 randomised blocks of 2 main plots each, each main plot subdivided into 4 sub-plots. The size of the main plots was about 3½ chains x ½ chain. Treatments were:—

A = 8-10 ins. ploughing after harvest.
B = 4 ins. „ „ „
P = natural grass or weeds.
Q = green manure.
R = bare fallow.
S = short before fallow, followed by short-term crop.

No attempt could be made to execute this programme, and in the 1948-9 season the experiment comprised only treatments A and B, which were first ploughed during the second week in May, i.e. within the period regarded as "usual time." The land was harrowed with a medium disc-harrow 15th to 17th June; ploughed again to the same depth as before 27th June to 8th July; disc-harrowed again 27th and 28th July; and harrowed for the last time on 29th July. Seeds were dibbled by hand in the normal Kelantan fashion on 29th to 31st July.

Penetration tests were made in the same way as for the preceding experiment, and the following figures were obtained:—

	A	B
	ins.	ins.
At planting ..	7.4	6.2
At weeding ..	6.8	5.7

There were no important visible differences between treatments until October, when treatment A developed a very dark green colour and began to outstrip B in growth, the difference being very easily visible from the air. The appearance was estimated with a scoring card, the points given for evenness of height, colour and weed control being as follows:—

	A	B
October ..	16.2	9.6
December ..	13.8	7.6

The superiority of treatment A was at no time in doubt after October.

Table V gives a summary of treatment means for the times taken in tractor or man hours per acre for the various cultural operations.

Table V.

Average Treatment Working Times.

(in tractor or man hours per acre)

Cultivation	Treatment	
	A	B
First ploughing ..	4.7	3.9
First harrowing ..	1.0	1.0
Second ploughing ..	1.9	1.5
Second harrowing ..	0.7	0.7
Third harrowing ..	0.8	0.8
Total mechanical ..	9.1	7.9
Planting (hand) ..	21.5	21.5
Weeding once (hand) ..	88.6	99.8
Supplying ..	57.3	32.8
Total ..	167.4	154.1
Cutting (sickle) ..	47.2	37.2
Threshing (tong) ..	42.0	28.1
Total ..	89.2	65.3

These figures are in good agreement with those for the experiment on depths and times of cultivation. The deeper ploughing again took rather longer, and although weeding required less work seedling mortality was somewhat higher and more supplying was required. The increased time for the harvesting operations for treatment A is connected with the increased crop.

The mean yield of padi obtained from treatment A was 94.0 lbs. per plot of ⅛th acre, as compared with 59.8 lbs. from treatment B. The increase of 57.2 per cent. is a significant one.

Tiller counts showed a mean of 9.3 per plant on plots of treatment A, as compared with 8.1 for treatment B. The increase in yield is therefore primarily due to heavier ears.

Plots of treatment A were not ready to harvest until 8 days after those of treatment B.

Drill Trials.

Four randomised blocks of 8 plots each were laid down to test the following combinations of drills, spacing, and seed rates.

A = Mitchell drill, 21 ins. spacing, higher seed rate.
B = „ 7 ins. „ „ „
C = *Menugal* (dibbling) (control).
D = Mitchell drill, 14 ins. spacing, lower seed rate.
E = „ 7 ins. „ „ „
F = „ 14 ins. „ higher „
G = „ 21 ins. „ lower „
H = Trusty seed drill attachment, 12 ins. spacing.

The experiment was undertaken with the object of obtaining some information on the seed rate and spacing which would be required for dry padi when sown by mechanical methods. The customary local method is to dibble about 5 seeds per point at a spacing of 1 ft. each way, which is equivalent to a seed rate of about 25 lbs. per acre. As far as is known, no attempt has ever been made by small-holders to sow seed in a continuous drill, and no information was available as to the reaction of the padi to close spacing within the row.

Preliminary tests of the drills showed delivery rates considerably in excess of 25 lbs. per acre, and although it was found possible to effect some reduction with the Mitchell drill, the lowest seed rate was still above that which was thought to be appropriate; in the case of the Trusty drill attachment it could not be reduced below about 50 lbs. per acre.

The land for the trial was cultivated to a depth of 4 ins. by mechanical means, but the weather broke shortly after drilling had commenced and after some considerable delay the work was completed under very poor conditions for both drilling and germination. There was standing water on the land for some days after drilling, and germination was patchy.

During the growing season it was clear to the eye that the lower seed rate was still too high for dry padi. The 7 ins. spacing made weeding an extremely difficult operation, and there was no suggestion that the closer spacing of the padi did anything to suppress the weeds, the padi in fact being the plant which was suppressed.

The data given in Table VI are derived from treatment means.

As has been observed in other experiments the main labour demand came after planting. Weeding costs were perceptibly higher at the 7 ins. spacing.

Table VI.

Labour for Cultural Operations.

(tractor or man hours per acre)

Cultivation (Mechanical)	
Ploughing (4 ins.) ..	1.9
1st harrowing ..	0.6
2nd „ ..	0.9
3rd „ ..	0.8
4th „ ..	0.7
5th „ ..	0.5
	5.4

Cultivation	Treatment							
	A	B	C	D	E	F	G	H
Drilling (Mechanical) ..	0.7	0.7	—	1.4	1.5	1.0	1.3	3.4
Hand planting ..	—	—	27.4	—	—	—	—	—
Hand weeding ..	115.0	183.3	156.1	146.0	154.1	130.2	129.5	128.4
Supplying ..	—	—	79.4	—	—	—	—	—
Total ..	115.7	184.0	262.9	147.4	155.6	131.2	130.8	131.8

The following data supplementary to Table VI are available from a multiplication area which was sown with the Mitchell drill.

	A	B	D	E	F	G
Drilling	0.7	0.6	0.6	0.6	0.6	0.7
Weeding	119.7	126.6	57.0	83.2	73.8	102.3

At harvest, tiller counts were taken in 20 random 1 yd. lengths per plot, and the number of ears and blind tillers recorded for each foot of the yard length. These were most irregular in the drilled plots, partly as a result of imperfections in the drills and partly as a result of the patchiness of the stand brought about by poor soil conditions. Supplying was only possible in the dibbled (control) plots, and this no doubt accounts for the great uniformity of stand in these plots, the estimates of numbers of ears per plot varying by less than 2 per cent. In the drilled plots the variation between the mean number of tillers per 20 1 yd. lengths exceeded 100 per cent. in several treatments.

A summary of tiller counts is given in Table VII.

Table VII.

Summary of Tiller Counts.

Mitchell Drill.		Mean No. of Tillers per 20 1 yd. lengths.	
Higher Seed Rate.		Ears	Blind Tillers
25 lbs. per acre.	A. 21 ins. ..	602	150
29.7 „ „	F. 14 ins. ..	382	43
37.3 „ „	B. 7 ins. ..	246	22
Lower Seed Rate.			
14.3 lbs. per acre.	G. 21 ins. ..	487	35
28.5 „ „	D. 14 ins. ..	345	32
31.6 „ „	E. 7 ins. ..	282	26
Trusty Seed Drill.			
49.5 lbs. per acre.	H. 12 ins. ..	496	119
Dibbling (Control)		Mean No. of Tillers per 20 hills.	
25 lbs. per acre.	C. 12 x 12 ins. ..	127	14

Since the control plots were dibbled at 12 x 12 ins. spacing, the number of tillers per 20 hills should be multiplied by 3 to obtain a figure comparable with the number of tillers per 20 1-yd. lengths. It will be seen therefore that treatments F, D, and C, which were at approximately the same spacing, gave a closely similar number of ears and tillers. At the closest spacing of 7 ins., the number of ears per yard fell to a minimum, as did the size of the individual ears.

There were no significant differences between yields of padi from the different treatments; mean yields in lbs. per plot of 1/12th acre are given in Table VIII.

Table VIII.

Mean Yield of Padi.

(in lbs. per plot of 1/12th acre).

Spacing of Rows	Seed Rate			
	Normal Dibbling	Mitchell Drill		Trusty Seed Rate
		Lower Seed Rate	Higher Seed Rate	
ins.				
7 ..		31.3	26.9	
12 ..				29.6
12 (x 12 ins. in the rows)	28.7			
14 ..		30.8	25.0	
21 ..		28.3	29.4	

Supplementary data on yields derived from multiplication areas are given below in lbs. per plot of 1/6th acre.

	Higher Seed Rate (A, B, & F)	Lower Seed Rate (D, E, & G)
7 ins. spacing (B & E)	79.5	118.7
14 ins. „ (D & F)	94.9	95.4
21 ins. „ (A & G)	37.1	29.2

The evidence from the tiller counts and the yield figures is strongly suggestive that the maximum yield may be found to be associated with a spacing of a few inches only between the rows, and a few inches in the row, i.e. comparable to what is achieved by broadcasting. Such a method of seeding is used, for example, in Trengganu, where however it is liable to result in very small yields owing to the practical difficulties of weeding, the benefits of which are not confined to the elimination of competing weeds, but include a great improvement in the growth of the padi following the surface cultivation and aeration of the soil. It appears likely therefore that, under the more intensive methods of cultivation followed in Kelantan, the small-holder has adopted a method of seeding which potentially is fairly high yielding and in practice is likely to be as high as any other by reason of the ease with which weeding and inter-cultivation can be done. The same consideration will apply to mechanical methods of sowing, which appear to be capable of giving no less high yields, but which will have to be associated with much better weed control than has been achieved during the first season, and with some form of light surface cultivation during the early stages of growth of the crop.

Trial of Horticultural Machines.

An experiment was laid down at Melor Experiment Station in the form of 4 randomised blocks of 4 plots each (plot size about 2½ chains x ½ chain) to compare the yields of padi obtained from land which had been cultivated with horticultural machines and with the Kelantan plough and harrow. Treatments were as follows:—

A = Trusty tractor and associated equipment.
B = Howard Gem rotary hoe.
C = B.M.B. tractor and associated equipment.
D = Kelantan plough and harrow.

This experiment had to be commenced soon after the arrival of the equipment, and operators could be given only the very shortest training in the use of the machines. Their unfamiliarity with them, and their lack of skill and experience, resulted in a very rough job being done, and it does not necessarily follow that the results of this experiment give a true indication of the potentialities of any one machine. The rotary hoe is the least likely to have been affected by the inexperience of the operator, followed by the Trusty and the B.M.B. in that order. Considerably more skill is required to do good ploughing with a horticultural tractor than is required say for a Fordson with power-lift plough.

Table IX.

Average Treatment Working Times.

(in tractor or man hours per acre)

Cultivation	Treatment			
	A	B	C	D
Ploughing ..	32.1	20.0	40.4	33.7
Ploughing ..	—	10.0	—	18.0
Harrowing ..	3.5	—	4.2	16.4
Ploughing ..	—	—	—	12.1
Harrowing ..	—	—	—	11.4
Ploughing ..	13.3	—	13.5	—
Harrowing ..	3.5	—	3.9	—
Ploughing ..	—	12.1	—	8.7
Harrowing ..	5.5	—	6.2	10.0
Ploughing ..	—	11.0	—	12.7
Harrowing ..	4.8	—	4.8	7.5
Total ..	62.7	53.1	73.0	130.5
Planting ..	43.5	43.5	43.5	36.7
1st weeding ..	213.6	175.5	256.1	229.8
2nd weeding ..	147.0	141.5	150.9	160.4
Supplying ..	31.2	34.6	46.0	38.3
Total ..	435.3	395.1	496.5	465.2

The first ploughing was undertaken between 25th May and 1st June, and the first harrowing, 17th to 19th June, the start being three to four weeks later than is desirable in a normal season. The control plots were

ploughed a second time on 17th June and harrowed on 10th July, and the rotary hoe plots 17th to 20th June. Other mechanical plots were ploughed and harrowed from 13th to 20th June and on the 17th July. Other operations were fitted in so that the land was ready for sowing on 21st and 22nd July. No attempt was made to perform the same number of operations on each treatment, the machines being used just as frequently as was considered necssary to bring the land into a fit condition to plant. Planting was done by hand in the usual manner (dibbling).

Table IX gives the average treatment working times in man or tractor hours per acre, expanded in a form to give an indication of the sequence of operations.

It appears that the rotary hoe (B) initially produced a rather cleaner seed-bed than did the ploughs, but that this early small advantage was lost by the time the second weeding was done.

Penetration tests made at planting time and after the first weeding gave the following estimates of depths of cultivation:

	A	B	C	D
	ins.	ins.	ins.	ins.
At planting ..	6.1	7.8	5.9	5.8
At weeding ..	5.8	6.2	5.5	5.3

These figures show clearly the fluffiness of the seed-bed produced by the rotary hoe, and that there was no very great difference in the depth of ploughing attained by the different ploughs.

Throughout the growing season there was not a great deal to choose between treatments, though the rotary hoe plots were very even and rather better than the others. Treatment means for marks awarded on visual differences are given below:

	A	B	C	D
End of October	15.0	18.1	12.7	13.5
Early December	12.0	14.0	10.5	10.7

The low marks awarded to treatment C, and to a less extent treatment A, were almost certainly on account of the poor standard of ploughing achieved by the operators.

Tiller counts at harvest indicated no differences between treatments.

Treatment mean yields, in lbs. per plot of 1/10th acre, are given below:

A	B	C	D
65.5	66.4	53.0	55.3

Summary.

1. Medium tractors, as typified by the Fordson Major, and standard equipment have been found quite suitable for use on dry padi land in Kelantan.

2. The improved growing conditions brought about by deeper ploughing following generations of shallow ploughing resulted in a large and statistically significant increase in yield.

3. There has been some evidence to suggest that the beneficial results from deeper ploughing may persist for several seasons.

4. There appears to be no reason to doubt that dry padi can be successfully planted with a standard seed drill, though the local method of dibbling facilitates inter-cultivation and weeding.

5. Estimates have been given of the amount of labour which is required for planting dry padi by local methods. On account of the small size of the plots, the rates of working of mechanical equipment were under estimated.

6. No opinion is expressed as to whether the use of mechanical equipment is economically practicable.

7. The horticultural machines tested failed to produce a statistically significant increase in yield of padi, and gave little promise of finding a place in small-holding agriculture. Their performance was however handicapped by inexperienced operators.

Acknowledgement.

Grateful acknowledgement is made of the work of the staff engaged on these experiments, and in particular that of Che Hassan bin Haji Abdullah, Agricultural Subordinate-in-charge, Melor Experiment Station.

INVESTIGATIONS INTO THE MECHANICAL CULTIVATION OF WET PADI IN PROVINCE WELLESLEY DURING THE SEASON 1948-1949

BY

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Investigations during the past season may be conveniently divided under three heads:—

(a) Agronomic.
(b) Engineering.
(c) Exploratory.

Agronomic investigations were based on recommendations made by the Standing Committee on Crop Investigations and consisted of experiments laid down at Bukit Merah Padi Experiment Station and referred to as Bukit Merah Nos. 7, 8 and 9.

Engineering developments included the design, construction or modification of wheels, tractors and implements, in the light of actual experience in Province Wellesley.

Exploratory investigations were not confined to Bukit Merah Station but also went further afield with the object of testing different tractor/implement combinations under varying and hitherto untried conditions.

(a) Agronomic Investigations.

Three mechanical cultivation experiments were laid down at Bukit Merah Padi Experiment Station during the 1948-49 season, two of which, Bukit Merah Nos. 7 and 8 were concerned with depth of cultivation and the third, Bukit Merah No. 9, with time and depth of cultivation.

Bukit Merah Nos. 7 and 8 were similar in that they each contained deep and shallow treatments, but No. 8 included additional buffalo treatments.

Bukit Merah No. 9 was designed to test the effect of both deep and shallow cultivations carried out early, normally and late in the season.

At Bukit Merah it was, unfortunately, only possible to replicate the treatments of Bukit Merah No. 7 once, and it was not possible to replicate treatments in Nos. 8 and 9 at all. Plots were approximately 1/12th acre in experiment No. 7 and 1/10th acre in experiments 8 and 9 and these sizes proved rather small for convenient working. Water control was not, owing to the drought, as good as it is in a more normal year.

Bukit Merah No. 7—Depth of Cultivation.

This experiment was designed to test the effect of intermediate depth ploughing and shallow ploughing on both the off and main season padi crops.

Treatments, which were duplicated, were as follows:—

Plot	Off-season	Main season
A	Fallow	Buffalo cultivation.
B	Intermediate depth ploughing	Intermediate depth ploughing.
C	Shallow ploughing	Shallow ploughing.

Plot sizes were 25 x 150 ft.

OFF-SEASON 1948.

Cultural Operations.

B Plots. Ploughed on 4th April, 1948, with Fordson Major and McCormick Deering 2-furrow mould-board plough to an average depth of 8 ins.

C Plots. Ploughed on 1st April, 1948, with B.M.B. Plowmate walking-type tractor, with single-furrow mould-board plough to an average depth of 4 ins.

B and C Plots. Cultivated on 19th and 22nd April, 1948, with Howard " Gem " rotary hoe.

During the cultural operations the land was fairly hard and dry.

B and C Plots. Transplanted on 30th April, 1948, with Tai Chu 65 seedlings at 4 plants per hill. Age of seedlings: 26 days.

Other details during the growing period were as follows:—

1948	
25-26th May	Weeding.
1st June	M.F. No. 1 mixture applied to all plots at 4 ozs. per sq. yd.
28th June	Flowering started.
17th July	Flowering ceased.
6th Aug.	Ripening started.
13th Aug.	Harvesting.

There was no damage to the crops and growth was good, though there was a slight yellowing of the plants in the B (intermediate depth ploughing) plots in the early stages, which persisted for about 1 month.

Yields.

Treatment.	Lbs. per plot of 3,750 sq. ft. A	B	C
	—	168	156
	—	163	169
Totals.	—	331	325

Results.

There was no marked difference in yields between the intermediate depth (8 ins.) and the shallow (4 ins.) ploughed plots.

MAIN SEASON 1948-49.

Cultural Operations.

A Plots.

1948	
21-24th Aug.	Slashing.
28th & 30th Aug.	Buffalo ploughing.
12th Sept.-2nd Oct.	Buffalo harrowing four times.

B Plots.

1948	
25th Aug.	Ploughing with Fordson Major using McCormick Deering 2-furrow mould-board plough at an average depth of 8 ins.
20th Sept.	" Paddle wheel " cultivation using Fordson Major running light.
(Plot 1 only) 2nd Oct.	Rolled using Fordson Major and drum roller.

C Plots.

Under wet conditions it was found impossible to use the B.M.B. Plowmate, and the only alternative machine available to carry out shallow cultivation was the Tillmore rotary cultivator which was accordingly used.

1948	
25th Aug.	Cultivating using Fordson Major with Tillmore, to an average depth of 4 ins.
20th Sept.	" Paddle wheel " cultivation using Fordson Major running light.

Other details common to all plots were:—

1948	
27th Aug.	Sowing.
5th Oct.	Transplanting.
4th-6th Nov.	Weeding.
23rd Dec.	Flowering started.
1949	
8th Jan.	Flowering ceased.
3rd Feb.	Harvesting.
Variety.	Reyong 6.

Water was adequate and well distributed.

Yields.

Treatment.	Lbs. per plot of 4,356 sq. ft. A	B	C
	199.33	216.00	226.66
	202.00	218.66	221.66
Totals.	401.33	434.66	448.32

Results.

There is clearly no difference between deep and shallow mechanical cultivation, but the increased yield of mechanically cultivated plots over the buffalo ploughed plots is of the order of 10 per cent. and, in view of the similar results in Bukit Merah 8 both in the off and main seasons, this result is of some significance.

Bukit Merah No. 8.—Depth of Cultivation.

Like Bukit Merah No. 7, this experiment was designed to test the effect of intermediate depth ploughing and shallow ploughing on both the off and main season padi crops, but there was a difference in the number of buffalo treatments, as under:—

Plot	Off-season		Main Season
1	Intermediate depth ploughing	+ padi	Intermediate depth plough.
2	Shallow ploughing	+ padi	Shallow plough.
3	Buffalo ploughing	+ padi	Buffalo plough.
4	Buffalo ploughing	No padi	Buffalo plough.
5	No cultivation	No padi	Buffalo plough.

Treatments were unreplicated and plot sizes were $\frac{1}{2}$ x 2 chains.

Off-season 1948.

Cultural Operations.

Plot 1. Ploughed on 5th April, 1948, with Fordson Major and McCormick Deering 2-furrow mould-board plough to an average depth of 8 ins. Cultivated on 22nd April, 1948, with Howard " Gem " rotary hoe.

Plot 2. Ploughed on 20th April, 1948, with B.M.B. Plowmate and single-furrow mould-board plough to an average depth of 4 ins. Cultivated on 30th April, 1948, with Howard " Gem " rotary hoe.

Plot 3. Buffalo ploughed on 6th April, 1948. Buffalo raked four times between 13th April and 3rd May, 1948. Buffalo rolled on 5th May, 1948.

Plot 4. Buffalo ploughed on 6th April, 1948.

Plot 5. Nil.

Plots 1, 2 and 3 were transplanted on 5th May, 1948, with Ryushu using 4 plants per hill, seedlings 24 days old.

Other observations were as follows:—

1948	
28th May	Weeding.
31st May 10th June	Manuring with M.F. No. 1 Mixture at 4 ozs. per sq. yd. in two applications of 2 ozs. each.
5th July	Flowering started.
28th July	Flowering ceased.
12th Aug.	Ripening started.
15th Aug.	Harvesting.

Plots 1 and 2 suffered from shortage of water; and Plot 3 from a slight attack of stem borers.

Yields.

	Lbs. per plot of 4,356 sq. ft.
Plot 1.	160
Plot 2.	154
Plot 3.	122

Results.

There was little difference in yield between intermediate depth and shallow mechanical cultivation, but each was better than the buffalo ploughed plot.

Main Season 1948-49.

Cultural Operations.

Plot 1.

1948	
26th Aug.	Ploughing with Fordson Major using McCormick Deering 2-furrow mould-board plough at an average depth of 8 ins.
17th-25th Sept.	Harrowing with Fordson Major using half set of McCormick Deering 15½ ins. diameter disc-harrow.
1st Oct.	Rolling with Fordson Major using " Single Kedah " roller.

Plot 2.

1948	
17th Sept.	Cultivating with Fordson Major and Tillmore rotary cultivator to an average depth of 4 ins.
25th Sept.	Harrowing (as in Plot 1).
1st Oct.	Rolling (as in Plot 1).

Plot 3.

1948	
31st Aug.	Ploughing with buffalo.
14th Sept. to 2nd Oct.	Harrowing with buffalo four times.
2nd Oct.	Rolling with buffalo.

Plot 4.

1948	
30th & 31st Aug.	Slashing.
31st Aug.	Ploughing with buffalo.
14th Sept.-2nd Oct.	Harrowing (as in Plot 3).
2nd Oct.	Rolling (as in Plot 3).

Plot 5.

1948	
2nd and 3rd Sept.	Slashing.
3rd Sept.	Ploughing with buffalo.
14th Sept.-2nd Oct.	Harrowing (as in Plot 3).
2nd Oct.	Rolling (as in Plot 3).

All Plots.

1948	
27th Aug.	Sowing.
3rd Oct.	Transplanting.
17th-19th Nov.	Weeding.
22nd Dec.	Flowering started.
1949	
8th Jan.	Flowering ceased.
3rd Feb.	Ripening started.
6th Feb.	Harvesting.
Variety.	Reyong 6.

Water was adequate and well distributed.

Yields.

Plot	Lbs. per plot.
1	249.66
2	244.00
3	230.00
4	221.66
5	218.66

Results.

Differences in yield were very slight but mechanical cultivation has again given higher yields than buffalo cultivation.

Bukit Merah No. 9—Time and Depth of Cultivation.

This experiment was designed to test the effect of intermediate depth and shallow cultivation, and the time of these operations, on the yield of wet padi.

Treatments, which were unreplicated, were as follows:—

1. Intermediate depth ploughing after harvest. (Early).
2. Shallow ploughing after harvest. (Early).
3. Shallow ploughing just before planting. (Late).

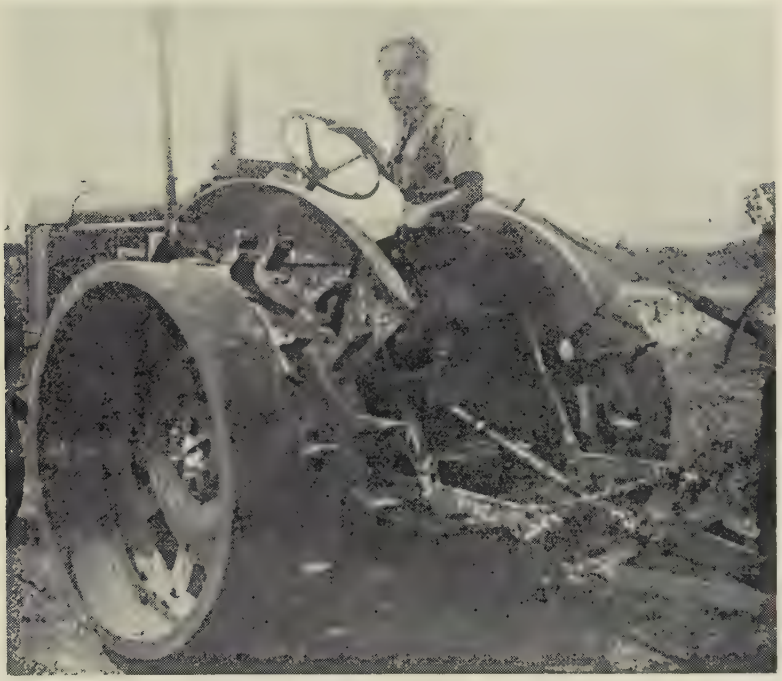

PLATE I.

First stage in the development of the "P.W. Solid Extension Wheels" showing the 10 ins. extension rim fitted to lug-shod steel wheel.

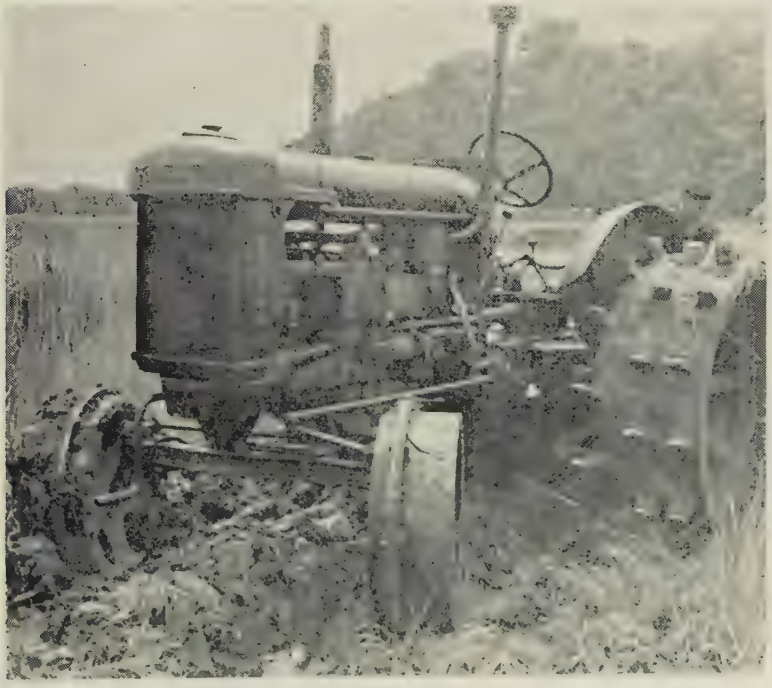

PLATE II.

The addition to the extension rim of 3 ins. lugs, similar to those fitted on the standard wheel. A 6 ins. extension rim has been fitted to the front wheels.

PLATE III.

The substitution of large strakes for the original lugs. The strakes are steel plates 10 ins. long and 6 ins. deep, set at an angle of 20° across the circumferential plane of the wheel.

4. Intermediate depth ploughing at cultivator's time. (Normal).
5. Shallow ploughing at cultivator's time. (Normal).
6. Buffalo ploughing at cultivator's time. (Control).
7. Intermediate depth ploughing just before planting. (Late).

Plot sizes were ½ x 2 chains.

Cultural Operations.

Plot 1.

1948	
5th April	Ploughing with Fordson Major using McCormick Deering 2-furrow mould-board plough at an average depth of 8 ins.
21st July	Harrowing with Fordson Major using single-gang of McCormick Deering 15½ ins. diameter disc-harrow.
16th Sept.	As on 21st July, 1948.
30th Sept.	Rolling with Fordson Major using " Single Kedah " roller.

Plot 2.

1948	
6th April	Ploughing with B.M.B. Plowmate using single-furrow mould-board plough at an average depth of 4 ins.
21st July	Cultivating with Howard " Gem " rotary hoe.
21st Aug.	As on 21st July, 1948.
18th Sept.	As on 21st July, 1948.
30th Sept.-2nd Oct.	Buffalo rolling with " Single Kedah " steel roller.

Plot 3.

1948	
16th Sept.	Cultivating with Fordson Major and Tillmore rotary cultivator at an average depth of 4 ins.
27th-30th. Sept.	Cultivating with Howard " Gem " rotary hoe.
2nd Oct.	Buffalo rolling with " Single Kedah " steel roller.

Plot 4.

1948	
9th July	Ploughing with Fordson Major using McCormick Deering 2-furrow mould-board plough at an average depth of 8 ins.
16th Sept.	Harrowing with Fordson Major using single-gang of McCormick Deering 15½ ins. diameter disc-harrow.
30th Sept.	Rolling with Fordson Major using " Single Kedah " steel roller.

Plot 5.

1948	
6th-15th July	Ploughing with B.M.B. Plowmate using single-furrow mould-board plough, at an average depth of 4 ins.
16th Sept.	Cultivating with Fordson Major using Tillmore rotary cultivator.
21st-30th Sept.	Cultivating with Howard " Gem " rotary hoe.
2nd Oct.	Buffalo rolling with " Single Kedah " steel roller.

Plot 6.

1948	
7th July	Buffalo ploughing.
16th Aug.-2nd Oct.	Buffalo harrowing four times.
2nd Oct.	Buffalo rolling.

Plot 7.

1948	
17th Sept.	Ploughing with Fordson Major using McCormick Deering 2-furrow mould-board plough at an average depth of 8 ins.
25th Sept.	Harrowing with Fordson Major using a single-gang of McCormick Deering 15½ ins. diameter disc-harrow.
30th Sept.	Rolling with Fordson Major using " Single Kedah " steel roller.

All Plots.

1948	
27th Aug.	Sowing.
4th Oct.	Transplanting.
26th-29th Oct.	Weeding.
22nd Dec.	Flowering started.
1949	
8th Jan.	Flowering ceased.
3rd Feb.	Ripening started.
5th Feb.	Harvesting.
Variety.	Reyong 6.

Water was adequate and well distributed.

Yields.

	Lbs. per plot.		
Depth	Early	Normal	Late
Intermediate.	227.66	230.00	221.66
Shallow.	249.33	238.00	218.66
Buffalo depth.	—	232.00	—

Results.

There were no very wide differences between treatments, the variation between highest (Plot 2) and lowest (Plot 3) being 55 gantangs per acre.

PLATE IV.

Prototype drum fitted to prevent tractor bogging in "patchy" land.

PLATE V.

For the final cultivation "paddle-wheels" were fitted to prevent sinking. The modified drum is also shown.

PLATE VI.

To assist steering, the front "paddle-wheels" were exchanged for "P.W. Solid Extension Front Wheels."

PLATE VII.

A 2-furrow digger trailer type plough with modified wheels.

General Review of Results.

In all three experiments under review, there have been no wide differences in yields and, whereas in Bukit Merah No. 7 shallow cultivation gave a slightly higher yield than intermediate depth cultivation, this result was reversed, to the same degree, in Bukit Merah No. 8.

In Bukit Merah No. 9, however, shallow cultivation again proved slightly better than intermediate depth cultivation and, as was to be expected, early and normal cultivation times proved better than late cultivation.

There was a general trend, in all three experiments, showing mechanical cultivation to be better than buffalo cultivation.

(b) Engineering Developments.

It is under this head that probably the greatest advances were made in Province Wellesley during the past season.

With the exception of a few trials with a Farmall "A" wheeled tractor, which was considered to be too light and low powered for the work required of it, all other mechanical cultivation work was done using Fordson Majors as prime movers, two of these machines being available, one of which was fitted with a hydraulic power-lift attachment.

Wheels.

Up to the end of 1947, the only wheels which had been tried for wet padi work were the standard steel set, the rear wheels of which were fitted with spade lugs.

It had been shown that these wheels were not suitable for work in wet conditions, and the first essential was to develop a type of wheel capable of supporting the tractor on soft land and of converting torque into forward movement without undue slip.

The progressive stages in the development of what have now come to be called the " P.W. Solid Extension Wheels " are shown in Plates 1, 2 and 3, and may be summarised as follows:—

(1) The bolting-on to a standard lug-shod steel wheel, of a plain 10 ins. extension rim. (Plate 1).

(2) The addition to the extension rim of 3 ins. lugs, similar to those fitted on the standard wheel. (Plate 2).

(3) The substitution for the 3 ins. lugs of large strakes consisting of steel plates 10 ins. long and 6 ins. deep, set at an angle of 20° across the circumferential plane of the wheel. (Plate 3).

Front wheel design kept pace with that of the rear wheels and progressed from standard steel to extension steel, the latter consisting of a plain 6 ins. rim bolted to the standard steel wheel. This is clearly shown in Plates 2 and 3.

This combination of front and rear extension wheels proved eminently satisfactory over extended trials under varying conditions but it was found that in " patchy " land, i.e. where hard and soft patches alternated there

were considerable delays caused by bogging in the soft parts. To assist in overcoming this, a front roller was devised to prevent undue sinking of the forepart of the tractor. Once again the process of development was gradual, the prototype, which is shown in Plate 4, being solid, of too small a diameter, and too heavy; it tended in wet, dirty land to jam and collect vegetation in front rather than to roll over. Next, a larger, open-work roller was made. This was good in wet, muddy land, but in heavy clay or " sticky " areas it soon became useless as it filled with clay, became very heavy, and failed to turn. By encasing this open-work roller (in light gauge sheet steel) a satisfactory one was obtained. This is shown in Plate 5, which also shows the method of attachment, by clamping on to the front axle; this later proved a weakness since, whenever the front tended to sink on a turn, a sideways thrust was placed on the roller causing it to twist and become out of alignment.

In general, however, the front roller has not been found to be essential, but is at times beneficial.

For the final cultivation, where previous operations had caused the land to become softer and softer until even the solid extension wheels began to sink, " Paddle wheels ", a set of which were received from Serdang, came into their own.

The rear wheels of this set are each 30 ins. wide and fitted with strakes 3½ ins. high, while the front wheels are 15½ ins. wide, with strakes 2 ins. high; these wheels are shown in Plate 5. In practice it was found that the open-work front wheels made steering extremely difficult and they were eventually abandoned in favour of the " P.W. Solid Extension Front Wheels ", and this combination proved very successful in deep areas with a pan down to 18 ins. provided there was plenty of water. See Plate 6.

IMPLEMENTS.

Ploughs.

Two types of plough were in common use, the McCormick Deering and the Ransome 2-furrow, mould-board, digger trailer types and the Fordson-Ransome 3-furrow, mould-board, semi-digger direct-attachment type (i.e. to the hydraulic lift).

The former were first tried in standard form, but it was found necessary to modify them to the extent of enclosing the wheels with light gauge sheet steel to prevent them from filling with mud and clogging, and of fitting spuds to the land wheel to stop skidding and to enable the self-lift to work. See Plate 7. In this form the ploughs performed extremely well and turned a very satisfactory furrow. See Plate 8.

Trials with the Fordson-Ransome direct-attachment plough were disappointing; under the conditions at Bukit Merah the Fordson could only pull 2 furrows and, even after conversion to 2-furrow form difficulty was experienced in maintaining a reasonably even, shallow depth and there was

PLATE VIII.

Furrows turned by modified 2-furrow digger trailer type plough.

PLATE IX.

The semi-digger direct attachment type plough converted to turn two instead of three furrows.

PLATE X.

The uneven and incompletely turned furrows made by the semi-digger direct attachment type plough.

PLATE XI.

The front half of the McCormick Deering disc-harrow.

a constant tendency to bog down owing to too great weight. On more solid land where the McCormick Deering plough was working 100 per cent. efficiently, greater success was obtained but it was found difficult to get the two furrows even and, at the same time, keep the depth of ploughing to less than 6 ins. When the plough was lowered to plough to 9 ins. depth, a perfect furrow was turned but the tractor tended to be overloaded. A further difficulty proved to be that the plough could not be raised sufficiently high to clear the ground when the tractor was working in soft conditions; this is shown in Plate 9, and the uneven and incompletely covered furrows in Plate 10. Modification to the land wheel of the plough may improve the depth control.

Harrows.

Satisfactory results in wet land were achieved by using the front half of a very light McCormick Deering disc-harrow, having 15½ ins. discs and weighing 491 lbs., see Plate 11.

This implement did good work at Bukit Merah but the setting of the discs had to be carefully watched in order to avoid too great a drag, with subsequent bogging of the tractor.

Only on very few occasions was it found possible to use both the front and rear gangs.

Rollers.

Two types of roller, the " Kedah " and the " Drum " were constructed for use with Fordson Majors and were extensively used for after-cultivation during the season.

The Kedah-type roller was originally constructed as a double roller, see Plate 12, being made of steel, having a width of 5 ft., an overall diameter of 1 ft. and weighing 475 lbs.; in this form it was found to be of particular use on hard, lumpy land but on softer lumpy land mud tended to collect on the rolls, prevented them from turning and acted as an anchor to the tractor.

For these soft conditions the rear roller was removed, reducing the weight to 323 lbs. and the " Single Kedah " proved capable of doing good work on soft land.

For deep, really wet land, where even the " Single Kedah " tended to sink, the " Drum Roller " was devised and constructed, primarily for a final puddling operation; this roller consisted of two 45 gallon fuel drums mounted end to end on a long shaft and fitted longitudinally with wooden slats 3 ins. high; the whole was mounted on a light steel frame and directly attached to the hydraulic power-lift, see Plate 13.

The dimensions of this roll were: length 6 ft. 3 ins., diameter 22 ins. (excluding slats), and the weight could be varied between 372 and 1,138 lbs. by filling with water through the normal screw-on caps.

" Paddle Wheel " Cultivation.

Eventually as cultivation proceeds and the land becomes softer and softer, even the drum roller is found to be too heavy for the tractor and the solid extension wheels, with their big, 6 ins. strakes, tend to sink deeper and deeper. At this stage the big, open-work " paddle wheels " came into their own. Further (and final) cultivation can be carried out by fitting the front and rear " paddle wheels " and just running the tractor throughout the fields. The work is much slower than by rollers as only 50 ins. are covered at a time, but in really soft land is most effective.

Rotary Cultivators.

The Tillmore uses the screw-type principle of rotary cultivation and is driven from the power take-off. The close-up view in Plate 14 shows the modification of the wheels by enclosing them, again using light gauge sheet steel, made necessary by a tendency to fill with mud and so clog up.

This implement was first tried on padi land in a dry state and worked very well to a depth of 3 or 4 ins., but below that the tractor laboured badly and tended to stall. On " sticky " land it proved useless as the draught was so great that the tractor had insufficient power to overcome rolling resistance and operate the power take-off, and the rotary screw clogged up. In wet conditions, however, the machine worked very well, see Plate 15, and was self-cleaning as it worked. The depth of work was 4 ins. and the resulting state of the land was very favourably commented upon by the local cultivators, who do not like the deep cultivation of mechanical ploughing.

Harvesting Equipment.

Two machines were available for harvesting trials in early 1949, viz. the Allen motor scythe and the Lloyds auto-sickle.

The Allen motor-scythe is a low-powered, self-propelled grass mower with a 3 ft. cutter bar designed to cut at a height of about 2 ins. above ground level. Muddy conditions prevailed at the time of harvesting and it was found necessary to change the standard, narrow-section pneumatic tyred wheels for a pair of locally made steel wheels designed for working in off-season *menderong* (*Scirpus grossus*) growth. The specification of these wheels is: diameter 27 ins., width 6 ins., weight 100 lbs. each, and they were fitted with 2½ ins. spuds in two rows of ten spuds per row. In addition, they were totally enclosed in light gauge sheet steel.

Further alterations to the machine as received included the fitting of a right-hand, off-set cutter-bar, a matching right-hand swath-board and an 18 ins. mild steel extension at the rear end of the swath-board. In practice it was found that the cutter-bar was not sufficiently off-set and, in order to avoid running over the cut padi, the useful cut was limited to the 16 ins. of cutter-bar projecting beyond the offside wheel, i.e. 2 rows of padi; furthermore, owing to the inherent design of the machine, the

PLATE XII.
The "Kedah" type roller.

PLATE XIII.
The "Drum" type roller.

PLATE XIV.
The Tillmore rotary cultivator with modified wheels.

PLATE XV.
The Tillmore rotary cultivator working in wet conditions.

standard cutting height of 2 ins. could not be altered and the resulting long straw caused the machine to be smothered and choked to a standstill. It was concluded that, due mainly to the necessarily low cutting height and also to its low power, this machine is unsuitable for padi harvesting.

The Lloyds auto-sickle is, also, a self-propelled grass-mower but is fitted with a more powerful engine than the Allen and has the added advantage of having a cutter-bar which lends itself to height adjustment. The modifications carried out on this machine include the raising of the cutter-bar by mounting a steel shoe, 6 ins. wide by 14 ins. long at the lower end of a 15 ins. bar, the upper end of which is bolted to the centre of the cutter-bar guide; the handlebars were bent up correspondingly to give a comfortable operating position. A pair of swath-boards were made locally and fitted at each end of the cutter-bar, facing backwards and inwards, to guide the cut material clear of the wheels, and a pair of " fingers " made from mild steel rod, were fitted to the extremities of the cutter-bar, facing forwards. Under trial, it was found that the standard pneumatic-tyred wheels gave no grip whatever in the muddy conditions prevailing, and, such was the wheelspin, that no forward motion was achieved. It was felt, however, that when suitable steel wheels have been developed and fitted, this machine may give a good account of itself, particularly as it obviously has an ample reserve of power.

(c) Exploratory Investigations.

Much of the exploratory work has already been described under section (b) Engineering Developments, as these two aspects of mechanical cultivation investigations are largely complementary.

Bukit Merah Padi Experiment Station, which is the headquarters of the mechanical team, was used as the principal centre for trying out new tractor-implement combinations and new modifications, and not only is this site suitable from the point of view of being centrally situated, but it also commends itself by reason of the fact that it is representative of a quite considerable proportion of the Province Wellesley padi lands, and, moreover, it is not by any means one of the easiest areas to work. It can, therefore, be quite safely assumed that if a certain operation can be performed successfully at Bukit Merah, it can also be equally or more successfully carried out in a larger number of other places in Province Wellesley.

The position at the end of the 1947-48 season was that ploughing had been found to be possible on certain wet padi lands in Province Wellesley providing there was a certain amount of vegetation present, but that after-cultivation could not be carried out with the equipment available. By the end of the 1948-49 season, as a result of the adoption of the modifications already described and of experience derived from a wider application of mechanical cultivation investigations, it was found possible not only to plough most types of land, but also to complete after-cultivation on a large

proportion of them. It must be stressed that this advance was, in part, due to the experience gained by the operators concerned, and it cannot be expected that dry land operators, however skilful, could turn to wet land operations and immediately achieve successful results; the training of operators, is in fact, a *sine qua non* of successful wet padi cultivation. The second factor which contributed to the advance, was the wider application of exploratory investigations. It has already been mentioned that Bukit Merah Padi Experiment Station was used as the principal centre for trying-out new modifications and new tractor-implement combinations, and much of the exploratory work was done there, but, on a purely acreage basis, more mechanical cultivation work was done outside the Station than within it.

Arrangements were made with cultivators at Sungei Derhaka, Province Wellesley North, to carry out full-scale mechanical cultivation trials on their land for purposes of timing and costing the various operations. Throughout the trials the prime-mover used was the Fordson Major, fitted with front and rear extension wheels, and, apart from very considerable and useful experience, the following data were obtained. The costs shown include estimated figures for depreciation and repairs.

Ploughing (using McCormick Deering 2-furrow, mould-board trailer-plough).
34.9 acres ploughed in 97.52 hrs. at a cost of $11.44 per acre.

Harrowing (using front gang of McCormick Deering 15½ ins. diameter disc-harrow).
5.54 acres harrowed in 8.05 hrs. at a cost of $5.77 per acre.

Rolling

(a) using " Double-Kedah " roll.
3.92 acres rolled in 5.05 hrs. at a cost of $6.13 per acre.

(b) using " Single-Kedah " roll.
11.64 acres rolled in 18.5 hrs. at a cost of $5.40 per acre.

(c) using " Drum " roll.
11.88 acres rolled in 9.3 hrs. at a cost of $3.83 per acre.

Rotary Cultivation (using Tillmore rotary cultivator).
5.49 acres (previously ploughed) cultivated in 4.3 hrs. at a cost of $4.28 per acre.

As a result of these trials, which were closely and critically watched throughout by cultivators from neighbouring padi areas, the Department was approached by Penghulus* and Ketuas* with the request that their lands should be mechanically cultivated on a contract system. As a result of these representations, an area of 11.65 acres was ploughed, and 3.50 acres Tillmore cultivated at Kampong Belah Dua on behalf of the owners or occupiers.

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* Local Headmen.

Times and costs of these operations were as follows:—

Ploughing 11.64 acres in 35.10 hrs. at a cost of $11.68 per acre.

Rotary Cultivating 3.50 acres in 6.6 hrs. at a cost of $8.12 per acre.

By the end of the 1948-49 cultivation season, therefore, considerable headway had been made in mechanical cultivation, and it was obvious that for the following season it would be desirable to continue and extend mechanical cultivation trials on a wider range of soil types and to endeavour to reduce both time and costs per acre. In this latter connexion it is evident that, before any sweeping reductions can be made, the problem of dealing with the very small padi fields must be vigorously tackled, and some attempt made to eliminate a large number of the " hereditary " bunds which at present divide so much of the padi land in Province Wellesley into uneconomic (from the mechanical cultivation viewpoint) units. Not only do small padi fields demand almost continuous turning and manoeuvring, and so raise both time and costs of operations, but they also result in a high proportion of uncultivated headland, when using trailer-type implements.

The obvious solution, but impracticable in established padi areas, is contour bunding. Failing this, the temporary ploughing-in of bunds during cultivation operations will have to be accepted as a necessary part of the mechanical cultivation of established padi lands, and these bunds, or such of them as are really necessary for water-control, could then be re-formed by the use of a mechanical grader or dozer blade. This is an aspect which requires further investigation.

Acknowledgements.

I am greatly indebted to Mr. H. J. Simpson, Agricultural Officer, Penang and Province Wellesley, until November 1948, for the material for the greater part of this article and from whose " Progress Report for the Season 1948-49 " I have freely quoted, and I cannot do better than quote Mr. Simpson's own acknowledgement: " I would stress that without the drive and enthusiasm of Mr. A. W. Van Ollenbach, Food Production Officer, who was responsible for all the work in the 1948 season, the mechanical trials in that year would have again been a failure. Equal credit must also be given to his mechanical team, who not only worked with a will, but above all worked as a team. Without such team work, experimentation can never be successful, as it demands courage and perseverance to go into areas that are difficult and where bogging is likely to be the rule rather than the exception." I would add that Mr. Simpson's remarks have applied with equal force both to Mr. Van Ollenbach and his team since I took over in November, 1948. Acknowledgement must also be made of the very great help given by Mr. J. A. Ewins who was responsible for most of the engineering modifications.

I am also indebted to Mr. Simpson for the photographs used for Plates I to XII.

MECHANICAL CULTIVATION EXPERIMENTS WITH WET PADI AT PULAU GADONG PADI EXPERIMENT STATION, MALACCA, IN 1948-1949

BY

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Introduction.

In March, 1948, it was decided to carry out in Malacca trials on the mechanical cultivation of wet padi, similar to those to be done in Kelantan, Province Wellesley and Perak. The land at Pulau Gadong available for this work is alluvial clay with a fairly constant sub-soil pan. It was also decided that all mechanical cultivation in the experiments at this Station should be done in the dry, since adequate water control could be obtained.

Mechanical cultivation trials were carried out on the same Station from 1935 to 1938. Although in 1935-36 some considerable success was obtained, later work was not so successful, with the result that the trials were eventually abandoned in 1938. In those trials it was found that the best yields were obtained when the land was ploughed twice, harrowed twice, and drilled at a wide spacing with a low seed rate. Good yields were also obtained when mechanical cultivation was followed by hand transplanting, chiefly, it was thought, on account of the ability to flood the land immediately after cultivation, thus preventing the excessive weed growth which normally occurred when the land had to be kept dry until drilled. Later trials with the same method were not, however, so successful and it appears that lack of adequate water control was the main cause of failure.

Preliminary Work for the 1948-49 Season.

Bearing in mind the history of the previous trials on this land, particularly with regard to adequate water control, the preliminary preparation of the experimental area was done with particular attention to its drainage and irrigation.

The experimental area to be used was formerly divided into 8 plots of approximately 1 acre each. These plots were considered to be too small for mechanical cultivation, and so the first work done consisted of the removal of the bunds dividing each pair of plots, giving four plots, each of about 2 acres. The earth from the dividing bunds was used to fill in the numerous buffalo wallows which were scattered over the area. After the removal of these bunds and the filling in of the wallows the plots were reasonably level, so that the only levelling work necessary was done by means of a levelling board after the cultivation of the plots.

After consultation with the Drainage and Irrigation Engineer, Malacca, a system of bunds and sub-drains between each of the four plots was constructed. The system was made so that the canals could serve for irrigation as well as drainage. The sub-drains were connected by wooden water gates and 9 ins. pipes to a main drain, which had a concrete control gate at the outlet. Irrigation was possible either by means of a pump from the Ayer Itam River or, in fairly wet weather, from a *tali ayer** from the Ayer Salak River. Two pumps were available, a portable Worthington-Simpson pump driven by a Fordson tractor and a smaller stationary pump driven by a Ruston diesel engine. The former delivered approximately 1 cu. sec. whereas the latter gave only about 1/5 cu. sec. It was frequently found necessary to use the larger pump because the newly constructed bunds were by no means water-tight.

Experimental Programme.

For the 1948-49 season it was decided that two experiments, similar to those to be carried out at other Stations under different soil and water supply conditions, should be undertaken.

The first experiment (Experiment "A") was one in which the variables were the time and type of tillage. The treatments were as follows:—

(a) After-harvest ploughing (April)
(b) Cultivators' time ploughing (May)
(c) Pre-planting ploughing (June)

each at (i) intermediate depth—8 ins.
(ii) shallow depth —4 ins.

(d) Cultivators' method ploughing with buffalo plough to 4 ins. depth at cultivators' time.

There were thus seven treatments, which were replicated in three blocks. Each plot was 272 x 28 ft. and the whole experiment, including a strip 50 ft. wide at each end of the plots for tractor turning, occupied 6 acres.

The second experiment (Experiment "B") was one in which the effect of off-season crops and bare fallow, following after-harvest tillage at two depths, on the subsequent growth of padi was studied. The off-season crop treatments were as follows:—

(a) Bare fallow.
(b) Food crop (sweet potatoes).
(c) Green manure (cowpeas and *Pueraria javanica*).
(d) " Grazing " (natural weed flora).

These four sub-treatments were randomised within the following tillage types:—

(1) Intermediate depth (8 ins.) after-harvest ploughing.
(2) Shallow depth (4 ins.) after-harvest ploughing.

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* *tali ayer* = irrigation canal.

The main plots (tillage) were 272 x 24 ft. and the sub-plots 68 x 24ft. There were four replications, totalling 2 acres, including the tractor turning area and guard rows.

Cultivation and Planting.

Experiment "A".

All work was done with a standard Fordson Major tractor fitted with steel wheels. The plough, which was used for both the 8 ins. and 4 ins. ploughing, was a McCormick-Deering 2-furrow mould-board plough.

Table I below shows the dates of all cultivations done on the experiment.

Table I.

Dates of Cultivation Operations on Experiment "A".

Type of Plot	Ploughing	Harrowing	Levelling	Drilling	Transplanting
After-harvest 8 ins. and 4 ins.	17th-20th April	21st-26th June	27th June	28th-29th June	—
Cultivators' time 8 ins. and 4 ins.	15th May	-do-	-do-	-do-	—
Pre-planting 8 ins. and 4 ins.	18th June	-do-	-do-	-do-	—
Cultivators' method ..	10th-11th May	30th July -2nd Aug.	3rd Aug.	—	4th Aug.

No difficulty was experienced in any of the above operations. The drainage system worked excellently and the land was dry enough to work within 24 hours of rain. The buffalo ploughing was done after heavy rain at a time when local cultivators did their first ploughing.

A total of 5 disc-harrowings was done with a Martin disc. Drilling at 10 gantangs of seed per acre at 7 ins. spacing between the rows was carried out with a Mitchell 7 ft. seed drill using the padi variety Siam 29. The cultivators' method plots were ploughed and harrowed in the usual way using buffaloes and local implements. They were transplanted by hand.

The total cost (for fuel and labour) of the mechanical operations, including drilling, worked out at approximately $28 per acre.

Experiment "B".

Ploughing on the deep ploughed plots was done with the same implements as were used in Experiment "A". For the shallow cultivation a 6 h.p. Plowmate was used initially, but it was unsatisfactory and eventually broke down. A rotary hoe was used instead.

The dates of the various operations carried out were as follows:—

Ploughing and rotary hoeing	6th-14th April.
Disc-harrowing (twice)	15th April.
Ridging for sweet potatoes	16th April.
Planting sweet potatoes and green manures	17th April.
Harvesting of sweet potatoes	12th July.
Disc-harrowing (4 times) and levelling ..	13th July.
Harrowing with local harrow	4th August.
Transplanting	5th August.

The yields of sweet potatoes were extremely poor. The deep ploughed plots yielded at a rate of 508 lbs. per acre and the rotary hoed plots at 313 lbs. per acre. There was no significant difference between these figures.

The green manure plots were sown with cowpea and *Pueraria javanica*, but the growth was very poor. The " grazing " sub-plots were allowed to grow up in natural vegetation which, in this case, consisted chiefly of self-sown padi. The bare fallow plots were kept free from weeds.

In July, in order to ascertain the effect of the ploughing on the sub-soil pan, a stick was pushed into the soil at 16 regularly spaced points on each sub-plot in Experiment "B". In the deep cultivated plots the stick went through the pan on an average once in every four points, whereas in the shallow cultivated plots it only penetrated on an average once in every thirteen points. The trial indicated that the pan was situated at an uneven depth below the surface and that ploughing at 8 ins. was insufficiently deep to break it up efficiently.

Growing Period.

Experiment "A".

The drilled padi in this experiment came up well in Blocks I and II, except in small patches, but in Block III there were larger patches where the seed failed to germinate. This patchiness was apparently due to uneven flooding after sowing and it would probably be better to allow the seed to germinate by rainfall only.

The subsequent growth of the padi was fair, although it soon became evident that there was far too thick a stand of plants in the rows and that 7 ins. spacing between the rows was insufficient. At the end of September, 1948, it was decided to try the effect of removing alternate rows of the drilled padi and of applying sulphate of ammonia at the rate of 2 cwts. per acre. These treatments, which were for observation purposes only, were each replicated six times and superimposed at one end of the plots in Block I. Individual plots were 30 x 28 ft. The treatments were started too late in the growing period to have much effect but, as expected, the plots dressed with sulphate of ammonia became greener and gave an increase in straw weight.

During the growing period five hand weedings were undertaken. The weights of weeds were recorded and the results are summarised in Table II.

Table II.

Weight of Weeds, expressed as Mean Weight in lbs. per Plot, Collected in Five Weedings from Experiment "A".

	Ploughed 8 ins.	Ploughed 4 ins.	Buffalo Ploughing
After-harvest ploughing ..	1,818	2,643	—
Cultivators' time ploughing ..	1,884	2,166	—
Pre-planting ploughing ..	2,275	2,606	—
Cultivators' method ..	—	—	2,216

Mean Weight = 2,230 lbs.

Although it appears that there was less weed growth on the plots ploughed to 8 ins. depth there is no statistical significance between either the type of ploughing or time of ploughing treatments.

Records of rainfall and the amount of water pumped on to Experiment "A" were kept in order to see what quantities were required to maintain good irrigation. The figures are summarised in Table III.

It will be seen that more than half the water used was supplied by rainfall and that, of the 37 ins. supplied by pumping, nearly half of it was used in two weeks in order to flood the plots after drilling and to flood again for transplanting the cultivators' method plots and the discard areas. Very much less water would have been required if the bunds surrounding the plots had been well consolidated.

Table III.

Amount of Water Supplied to Experiment "A".

(in inches per week).

Week No.	For week ending	By Rain	By Pump	Total
		ins.	ins.	ins.
1.	3rd July	1.50	0.80	2.30
2.	10th	1.96	1.04	3.00
3.	17th	0.63	—	0.63
4.	24th	0.74	9.44	10.18
5.	31st	4.10	1.44	5.54
6.	7th Aug.	2.99	—	2.99
7.	14th	1.42	8.24	9.66
8.	21st	2.16	1.76	3.92
9.	28th	0.23	3.44	3.67
10.	4th Sep.	1.10	1.44	2.54
11.	11th	1.76	1.04	2.80
12.	18th	2.01	0.48	2.49
13.	25th	3.78	—	3.78
14.	2nd Oct.	2.19	—	2.19
15.	9th	2.33	—	2.33
16.	16th	0.74	0.88	1.62
17.	23rd	0.91	0.56	1.47
18.	30th	3.85	0.36	4.21
19.	6th Nov.	2.47	—	2.47
20.	13th	1.65	0.24	1.89
21.	20th	1.88	0.32	2.20
22.	27th	1.29	—	1.29
23.	4th Dec.	—	—	—
24.	11th	0.71	0.88	1.59
25.	18th	—	1.86	1.86
26.	25th	1.90	2.84	4.74
27. (6 days)	30th	0.68	—	0.68
	Totals	44.98	37.06	82.04

Experiment "B".

Growth of the transplanted padi in Experiment "B" was excellent throughout the season and it was evident that no great difference between treatments could be found.

Four weedings were undertaken, on main plots only. No significant difference in plots ploughed to 8 ins. and in those which were rotary hoed to 4 ins. was found, the mean weight of weeds per lot being 1,255 and 1,174 lbs. respectively. It is thought that the use of local harrows (*sikat*) before transplanting may have evened out the weediness to some extent. The weight of weeds from this experiment was only just over 60 per cent. of that from Experiment "A".

Flowering started on both experiments early in December. In Experiment "A" large numbers of very small ears, borne on slender and short stalks, were formed. Much of the crop was lodged during December and January when there were strong winds almost daily. In the cultivators' method plots, which had been transplanted instead of drilled, better ears were produced. In Experiment "B" growth was good, and very little lodging occurred.

HARVEST.

Harvesting of Experiment "B" started at the end of January and of Experiment "A" early in February. Both experiments were harvested by hand, care being taken in Experiment "A" to cut the straw at a standard height from the ground, because straw weights were being recorded.

The yields of grain and straw are shown in Tables IV and V.

Table IV.

Experiment "A". Yields of Grain.

(expressed as gantangs per acre).

	Ploughed 8 ins.	Ploughed 4 ins.	Buffalo Ploughed
After-harvest ploughing ..	119.1	146.2	—
Cultivators' time ..	124.5	129.7	—
Pre-planting ploughing ..	125.4	155.6	—
Cultivators' method ..	—	—	174.5

Mean yield = 139.3 gantangs per acre.

Table V.

Experiment "A". Yields of Straw.

(expressed as lbs. per acre).

	Ploughed 8 ins.	Ploughed 4 ins.	Buffalo Ploughed
After-harvest ploughing ..	2,437	3,246	—
Cultivators' time ..	2,764	3,329	—
Pre-planting ..	3,041	3,700	—
Cultivators' method ..	—	—	3,656

Mean yield = 3,167 lbs. per acre.

Because of the very high variation between the blocks no significant differences were obtained, either in respect of grain yield or of straw weight. It is thought that most of the variation between blocks was caused by differences in their water supply and distribution, although there may also have been a fair amount of variation in soil fertility.

The grain yield from Experiment "B" is shown in Table VI.

Table VI.

Experiment "B". Yields of Grain.

(expressed as gantangs per acre).

	Sweet Potato	Bare Fallow	Green Manure	"Grazing"
Ploughing to 8 ins. ..	391.8	385.2	368.8	360.3
Rotary hoeing ..	341.5	363.9	380.9	480.2

Mean yield = 384.1 gantangs per acre.

In this experiment also there were no significant differences between any of the treatments.

Discussion of Experiment Results.

It appears from observations on the growing crop and from yields that drilling at 7 ins. spacing at 10 gantangs per acre is not very satisfactory It is thought that better results could be obtained by drilling at 14 ins. between the rows and using a smaller seed rate per foot run of drill. It is suggested that 3 gantangs per acre in 14 ins. drills would be sufficient.

The experiment will be repeated in 1949-50 with the wider drill spacing and it is hoped that a better and more vigorous crop will be obtained. If the variation between plots had not been so great some positive results from the treatments might have been obtained.

Experiment "B" will also be repeated, the only modification being the rotary hoed plots will be ploughed to 4 ins. depth. The crop last season was good, but it is thought that there was insufficient time between ploughing in April and the harrowing of all plots in mid-July for the sub-treatments to exert much influence on the results. It is suggested that ploughing should be done in March, immediately after harvest.

Harvesting.

The McCormick-Deering rice binder was received at Pulau Gadong in January, 1949, for trial. In all it was tried four times before sending it to Perak for further tests. Unfortunately it was not possible to use this machine on the mechanically cultivated plots, so it was used on another part of the Station. Here, however, no plots of more than 1 acre were available and it was not possible to do a prolonged test.

The machine was pulled by a Fordson Major quite satisfactorily on dry or damp ground and it work fairly well in padi which was erect, but had considerable difficulty in lodged or partially lodged padi. The sail could not be lowered sufficiently to push the padi on to the conveyor and 10 ins. extensions were accordingly made. The chief difficulty encountered was that the cut padi frequently jammed at the outside end of the cutter bar and conveyor, resulting in frequent stops to clear it and in untidy sheaves which sometimes became jammed in the sheaf expelling mechanism. It was not possible to rectify this fault before sending it away.

The best time made by the machine was 1¼ hours for cutting ¾ acre of padi. This is extremely slow, but could have been greatly improved on if the area to be cut were not so small and if the padi had been less ripe.

Acknowledgements.

The writer wishes to acknowledge the work of Mr. H. M. James who was in charge of the experiments at Pulau Gadong until the end of October, 1948, and the assistance of Mr. G. Egan, Drainage and Irrigation Engineer, Malacca, who advised on the lay-out of the drainage system.

INVESTIGATIONS ON THE MECHANICAL CULTIVATION OF PADI AT CHENDERONG BALAI, 1948-1949

BY

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Introduction.

Investigations carried out at Chenderong Balai in the Sungei Manik Irrigation Area, South Perak, commenced in June, 1947, and the results obtained up to the end of that year have already been described.(1). The present paper describes the continuation of that work up to April, 1949.

It has recently become apparent that the soils of most of the large areas of potential padi land in Malaya, now under swamp forest, consist of peats, mucks, and organic soils, collectively known as bog soils. Typical of these areas is that of some 160,000 to 200,000 acres to the west of the Perak River, known as the Trans-Perak area. The population factor alone precludes the early development of this and other areas by the time-honoured hand-methods of clearing and cultivation. It will thus be seen that the investigations at Chenderong Balai assume an added importance and that, provided these bog soils are typical of other large areas, the solution of mechanical cultivation problems there is of some urgency.

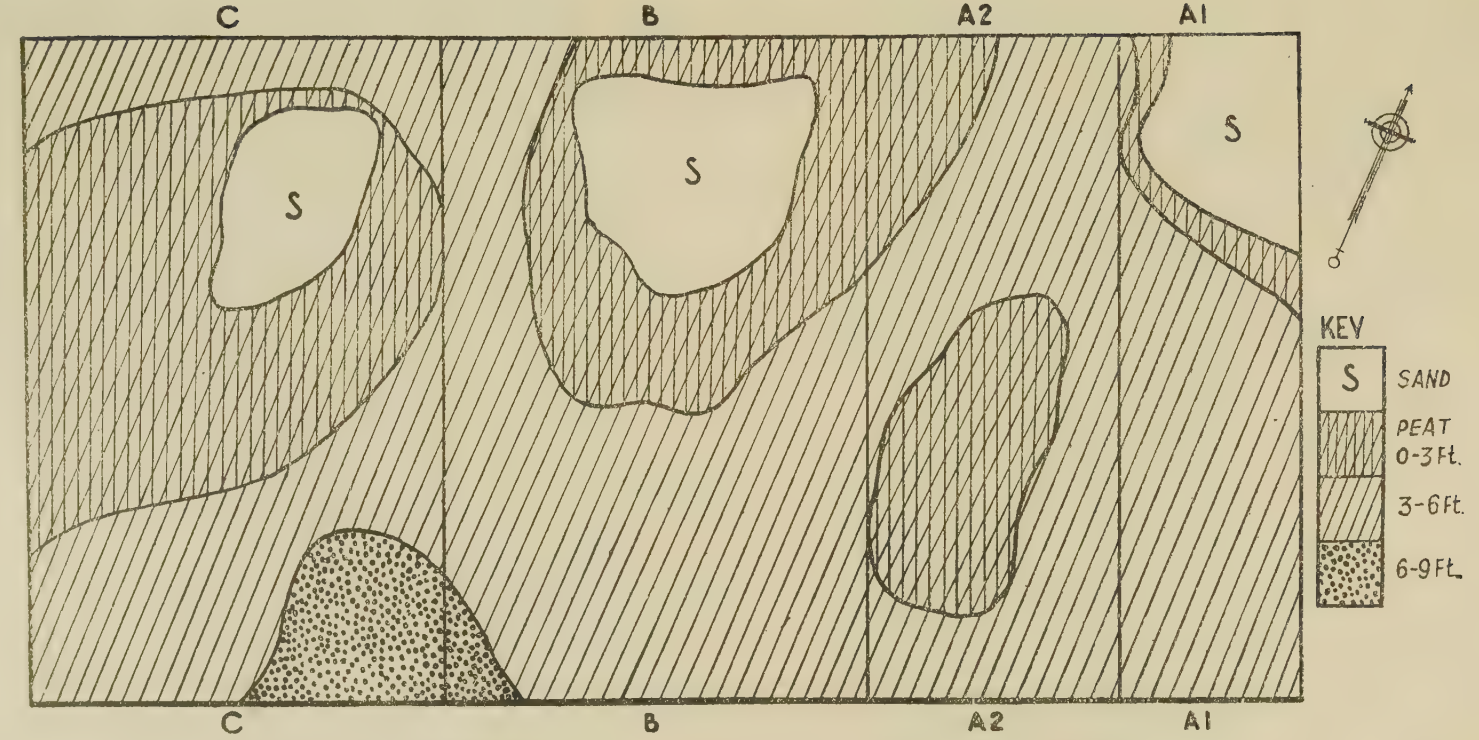
The whole Chenderong Balai reserve is 320 acres in area but only 84 acres have been opened up. Both the cleared area and the rest of the reserve have been examined in detail by a Soils Chemist, and his report (2) has revealed that some three-quarters of the area is covered with bog-soils varying in depth from 0 to 10 ft. From the soil-plan of the cleared area it will be seen that the average depth of peat in Block A is 3½ ft. and that in Block B somewhat more.

In order to compare the soils of the Trans-Perak area with those of Chenderong Balai we cannot do better than quote the following extracts from the Soil Chemist's report:—

> " Little of the (Trans-Perak) area was actually peat, most of it falling clearly into the class of muck soils. On the other hand, with the exception of the " Permatangs " (high sandy areas), most of the Chenderong Balai Station is peat soil but, as indicated earlier, the cultivated top soil has oxidised to give a type of muck soil on which the padi is being successfully grown."

PEAT CONTOUR MAP—CHENDERONG BALAI—PERAK

Scale: 1 inch = 6 chains.



" Experiments at Chenderong Balai will, however, serve two purposes:— (i) To find out to what extent padi will succeed on soil that has been verified as deep peat and (ii) To find out what is the most suitable machinery for timber clearing and cultivating such an area."

" It is hoped to clear and cultivate the Trans-Perak area by mechanical means and the experiments at Chenderong Balai are attempting this also. Peat depths at Chenderong Balai were as great as any encountered on the West Bank of the Perak River, and it would therefore seem that the two areas had common problems and presumably common solutions ".

From these extracts it may be concluded that conditions for mechanical cultivation of padi are likely to be more difficult at Chenderong Balai than west of the Perak River and that tractors and implements which can be used at the former locality are likely to be at least as successful at the latter.

Harvesting Trials, 1948.

In December 1947, about 53 acres were planted with Radin seedlings and 3 acres were drilled with the very short-term Haji Harun padi. Initial growth was satisfactory and the drilled crop was at least as healthy as the transplanted padi although much thicker. However, owing to the unavoidably late planting date the Radin crop was a complete failure as it failed to flower. The Haji Harun padi flowered uniformly and set seed towards the end of March.

Apart from a grass mower which did not prove satisfactory the only harvesting implement tried was a McCormick-Deering 52R harvester-thresher (combine-harvester) which did not arrive until April. Without modification its bearing-pressure was obviously too great for the soil so a large rigid-skid was designed and fitted. A trial on 24th April, 1948, showed that, even under the very wet conditions then prevailing, the flotation was adequate. However, the skid proved unsatisfactory as earth piled up in front and draft was excessive. Furthermore the skid differed from wheels in providing no resistance to lateral thrust and the whole implement tended to travel crab-wise.

At the time rain was frequent and heavy; the crop, although in ear, never become sufficiently ripe to cut, and the straw eventually rotted and collapsed. Thus there was no opportunity to test the mechanism of the Combine-Harvester but it was obvious not only that its use was dependent on weather conditions but also that the problem of grain drying would be a major one.

Clearing of New Land and Stumping.

Exploratory work in 1947 had shown that the mechanical clearing of swamp-jungle on bog-soils presented novel and major problems which must be tackled and solved before any method of mechanical cultivation

PLATE I.

T.D.6. tractor with 20 ins. shoes towing the McCormick-Deering 19B cut-away disc-harrow. Note the heavy off-season growth of Jussiaea.

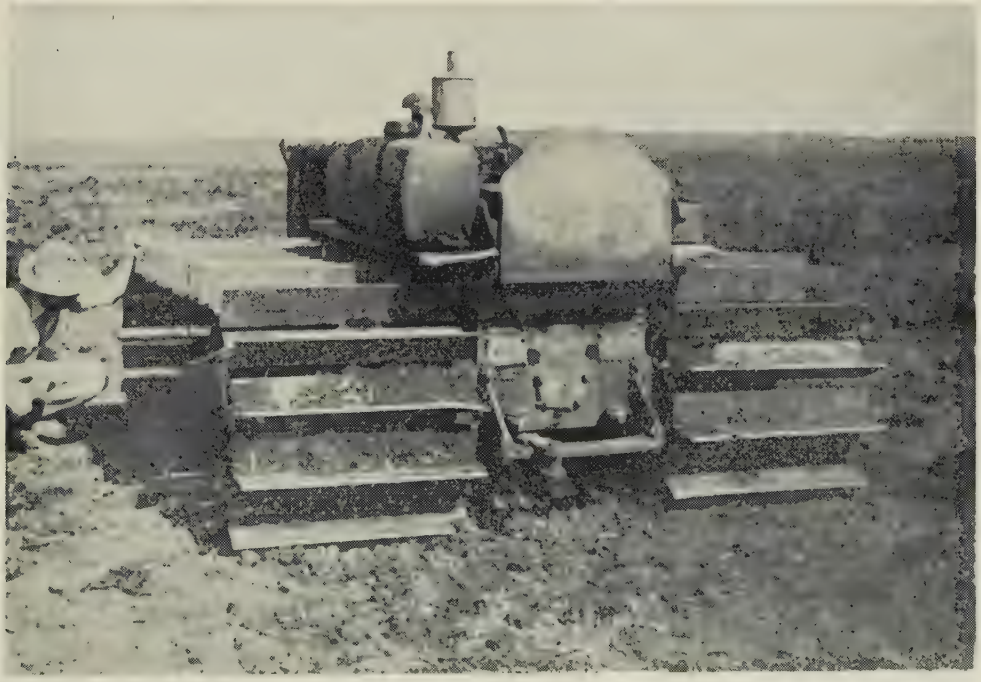


PLATE II.

D.4. tractor with 6 x 6 x 34 ins. M.S. angle-iron shoes. Note the greater track overhang outside than on the inside.

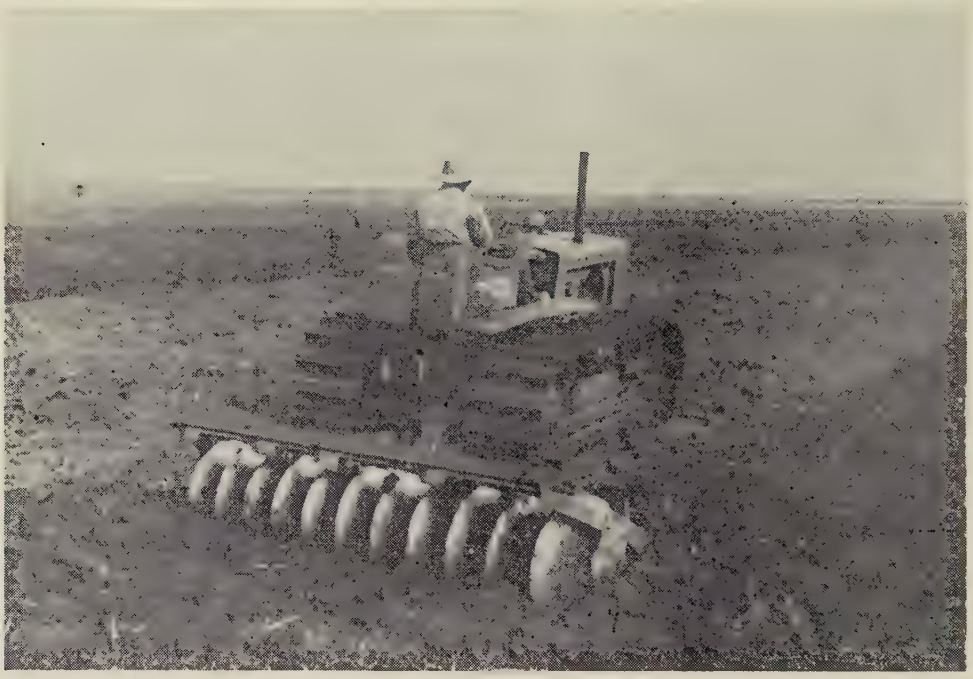


PLATE III.

T.D.6. tractor pulling the rear-gang of the Dyrr heavy disc-harrow.

PLATE IV.

D.4. tractor towing the Pacific Terracer constructing contour bunds.

of padi can be practised on new areas in Malaya. A somewhat ambitious programme was suggested for the continuation of this work but could not be proceeded with on account of lack of staff, funds and equipment.

Inter-Season Work.

The wet off-season in April and early May was devoted to the overhaul and modification of tractors and implements. This work was made possible by the use of a mobile work-shop.

The chief modifications carried out to tractors were aimed at the production of a machine with a bearing pressure of 2½ to 3 lbs. per sq. in. with a grouser shoe or wheel giving maximum power consistent with adequate bracing area. For this work one wheeled tractor, a Fordson Major, and five crawler track-tractors were available. The track-tractors were one International T.D.6, one International T.D.14 and three Caterpillar D.4 machines.

The Fordson Major tractor was modified by fitting special lattice-work wheels supplied by the Federal Experiment Station, Serdang. The rear wheels had a total width of 30 ins. each but the effective width was much less owing to the lattice-work structure. Four-inch grousers were fitted to give the necessary bracing area. Similarly the 15 ins. wide front wheels were fitted with 2 ins. grousers. Of the three D.4 track-tractors all were fitted with standard 13 ins. track shoes but two were wide-gauge machines capable of taking 20 ins. shoes. The narrow-gauge tractor was first converted into a wide gauge one and then locally made 6 x 6 x 34 ins. grouser shoes made from ½ in. mild steel angle-iron were fitted to two of the machines. In one of these tractors standard wide-gauge 24 ins. shoes alternated with the 34 ins. locally made ones, but subsequently the latter were fitted throughout. The third D.4 was fitted with 6 x 34 ins. mild steel shoes with a central 2 ins. grouser and with removable 2½ x 2 x 34 ins. hardwood road shoes on either side of the steel grousers. This design permitted the removal of half or all the wooden shoes according to the nature of the soil.

The widest balanced shoe that can be fitted to a wide-gauge D.4 would be 29 ins. in width. Hence the 34 ins. shoe is unbalanced and overhangs 5 ins. more on the outside of the track than on the inside. This overhang had been found to aggravate bogging-down on wet peat so it was filled up on one tractor by fitting light-weight tanks made from 1/16 and 1/8 in. mild steel plates.

The T.D.14 tractor required extensive repairs and it could not be used for cultivation work. Nevertheless it was fitted with locally-made 36 ins. wide balanced shoes with a central grouser 4 ins. high.

The more important technical details of the modified track-tractors are given in Table I. The wide-gauge International T.D.6 tractor was not modified.

Table I.

Particulars of Modified Track-Tractors.

Tractor Type ..	T.D.6	T.D.14	D.4	D.4	D.4
Estimated Weight in lbs. ..	9,260	19,228	14,224	12,062	13,094
Bearing Pressure (lbs. per sq. in.) ..	3.67	2.97	2.61	2.57	2.41
Maximum D.B. Horse-Power	29.49	54.04	35.68	35.68	35.68
Power/Bearing Area Ratio (i.e. 1 DBHP/Area in sq. ins.)	1:85	1:120	1:152	1:132	1:152
Number of Track-rollers ..	4	5	5	4	5
Size of Front-idler ..		large	large	small	large

Data quoted in Table I are calculated from the maximum draw-bar horse-power quoted by the manufacturers. These figures are usually determined on dry grass-land, and the effective power output on wet peat would be much less. Furthermore, on the modified tractors the very wide tracks and particularly the high grousers absorb considerable power. It should be noted, therefore, that the important power/bearing area ratios would, in practice, be much wider on the modified tractors than those quoted. In order to determine actual power-outputs on bog-soils it is hoped that a dynamometer will be available in the future.

Modifications to the seed-drill will be described in a later section.

Cultivations, 1948.

In Lower Perak the short wet season normally extends from early March until late May. June, July and early August are usually dry with occasional rain-storms. As irrigation water was due on the 15th July it was desirable to complete cultivation by that date in order to drill the crop at about the same time as Malay cultivators were sowing nurseries in the surrounding padi-fields.

The all-important weather was suitable for cultivation to have commenced in mid-May but essential implements were not available until after the 12th June. This date coincided with the beginning of a short spell of wet weather, and work had to be held up until the 26th June when cultivation commenced on double shift. A second set-back occurred with the outbreak of banditry, and the second author was seconded to the Police from the 25th June to 9th July, 1948.

By the 22nd July cultivation in Blocks A1, A2 and B (total area 56 acres) had been completed and the off-season growth had rotted down quite satisfactorily. This land preparation consisted of four harrowings, two in each direction, and a certain amount of *batas* (small bund) construction using the Pacific Terracer. In addition some 18 acres of Block C

(28 acres) had been harrowed twice but, as there was insufficient time for trash to rot down before irrigation, this block was abandoned in so far as mechanical cultivation and planting were concerned. This was obviously a wise decision because, for access reasons, Block B could not be irrigated if work was to continue in Block C. The latter block was given out to members of the daily-paid staff for hand cultivation.

Performance of Implements.

The following implements were available for part or all of the cultivation period:—

McCormick-Deering G.L.70 3-furrow disc-plough.
Tillmore (Tillmaster) rotary cultivator.
Martin light disc-harrow (4-gang).
McCormick-Deering 19B medium disc-harrow (4-gang).
Ransomes Baron No. 3 medium disc-harrow (4-gang).
McCormick-Deering " Dyrr " heavy disc-harrow (2-gang).

The G.L.70 disc-plough was given only a short trial and no other ploughs were used. It proved to be quite unsuitable, being both too heavy for the peat and of too weak construction. On the first trial all three cast-iron wheel-brackets broke on underground timbers. This showed that it was inferior in performance, on bog-soils, to the Australian Royal 14-furrow disc-plough, converted to 3-furrow, which was used in 1947.

The Tillmore is an implement with a revolving-worm or endless disc driven by the power take-off of the tractor. Lateral thrust is taken up by a rigid disc coulter on the land side. It is an interesting implement but proved to be quite unsuited to rough conditions. The disc was soon broken by underground timbers and the tractor power take-off was damaged.

The Martin disc-harrow proved to be too light for economic use by itself with a track-tractor. It also suffered from two other disadvantages: its angle adjustment was inadequate for effective work and it clogged up very easily owing to the narrow (6 ins.) disc spacing. However, the rear half of this implement proved an effective covering-harrow when hitched behind the drill.

The McCormick-Deering 19B cut-away disc-harrow was received minus one disc and subsequently lost another. Nevertheless it proved to be invaluable and, as in 1947, it was responsible for most of the cultivation. No discs were broken in spite of constantly hitting underground timbers since it is sufficiently non-rigid to bounce over these. Its name of " Bog " or " Brush-Harrow " suggests that it was designed for similar rough conditions in America. Important points in its design are the wide disc-spacing, its general sturdiness and the excellent type of scraper fitted.

The Ransomes disc-harrow, which was new when received, proved to be a most unexpected failure. It was tested on several occasions under different weather conditions and was found to be quite useless since it invariably clogged up within a few yards. Subsequently the front half alone

was tried but this also was unsatisfactory. Its disadvantages for use on bog soils were its rigidity, the narrow (6½ ins.) disc spacing, and the inefficiency of the trash-bars which were fitted instead of scrapers. It is only fair to note that a trial on hard clay soil without underground timbers showed this harrow to be quite useful, although the absence of a scraper was a bad fault and even lalang clogged it up badly.

Although the " Dyrr " two-gang disc-harrow was a good deal heavier than the 19B it was much less effective on the first cultivation round as it merely flattened the trash and did not cut through it. With the gangs fully-open its draught was excessive and, where underground timbers were frequent, its rigidity proved a disadvantage. However, it was put to very good use for second and subsequent cultivations as the rear-gang was used by itself with a temporary hitch at an angle of about 10°. In effect, it was used as a poly-disc harrow-plough without land-wheels. As such its draught was light and the T.D.6 was capable of pulling it in 4th gear. However, its small working angle made it unsuitable for use where much trash was present on the surface.

Batas or bund construction within the fields proved a major problem since no specialized implement was available. However, a No. 1 Pacific Terracer on 4 rubber wheels had been used for grading an earth road and it was tested for *batas* construction with maximum angle on the blade and the leading end working low. It proved to be moderately effective and a rough *batas* 1 ft. high could be made with 4 runs. Altogether 40 chains of *batas* were made but some hand patching was necessary. Naturally, underground timbers proved most troublesome and whenever the terracer dug itself into the soft moist peat it proved most difficult to extract. However, in spite of its light weight it is strongly built and suffered no damage from somewhat rough treatment.

Performance of Tractors.

The unmodified International T.D.6 tractor proved to be the best standard machine tested and was very easy to handle. It is not possible to make a fair comparison with the D.4 tractors because the latter are all old and were received in an unserviceable condition. Nevertheless, although its bearing pressure is 3.67 lbs. per sq. in. and therefore much higher than that of the D.4 tractors, it made up for a slightly increased tendency to slip and to bog down by a higher working speed. It could pull the 19B disc harrow in 3rd gear easily and, on good ground, it could work in 4th gear. On one day, under exceptionally good conditions, this machine harrowed the record area of 12 acres.

The three Caterpillar D.4 tractors have all done good work in spite of their age, and the different types of track shoes made possible some interesting comparisons in performance. The 6 x 6 ins. grouser shoe proved to be unsatisfactory: although the large grousers gave plenty of traction they broke up the soil crust and, at the slightest tendency to slip, the tractors dug themselves in.

PLATE V.

The Fordson Major tractor fitted with "paddle-wheels."

PLATE VI.

Close-up of the modified cylinder-wheel fitted to the Mitchell seed-drill. Note the 1½ ins. grousers and the inspection-hole covered by the removable plate.

PLATE VII.

Drilling in progress.
The D.4. tractor is towing the Mitchell seed-drill with the rear-gangs of the Martins disc-harrow hitched on behind as a covering-harrow.

PLATE VIII.

The young padi crop in Block A.I. one month after drilling with about 2 ins. of water on the ground. Note the 7 ins. drill-spacing and the absence of weeds.

It was hoped that it would be possible to test the different types of grousers in dynamometer experiments but, in the absence of such an instrument, reliance had to be placed on general observation of performance. It was finally decided that the 6 ins. grouser was uneconomic as the high rolling resistance absorbed so much power. The combination of 20 ins. shoes with 2 ins. grousers alternating with 34 ins. shoes with 6 ins. grousers proved in practice to have an even higher rolling resistance than when the 6 ins. grouser shoes were fitted throughout. Finally all the 6 ins. grousers were cut down to 2 ins. and there was a noticeable improvement in performance under wet conditions. Furthermore, under the very worst conditions, the wooden-faced tracks, without any bracing area, proved to be slightly more effective than the tracks with 2 ins. grousers.

When modifications to the T.D.14 tractor were finally completed in March, 1949, it was found to have a better performance on wet soil than the D.4 machines. That this was not due to a lower bearing pressure may be seen by reference to Table I. Its superiority is ascribed to the balanced shoes and to the narrower power/bearing area ratio. The 4 ins. grousers on this tractor were also cut down to 2 ins. as this size is considered to be the optimum.

The Fordson Major with lattice-work wheels was tested under good conditions on 27th June, 1948. It proved to be moderately promising but, even without an implement attached, it got stuck in slightly soft patches where the T.D.6 would have been unaffected. It was then hitched to a light disc-harrow and was found to have inadequate power to start. Three times the driver stalled the engine in bottom gear before it moved and then only with some assistance from three men. Subsequently it stuck at the first soft place before covering even 1 chain. An attempt to drive out the tractor after unhitching the harrow caused the rear wheels to sink to the axles. It may be concluded, therefore, that these wheels greatly increase rolling resistance and yet they give inadequate flotation on peaty soil.

Sowing and Growth of Padi.

It will be remembered that the Mitchell Combine Seed-Drill was modified by fitting the wheels with 9 ins. steel extension rims. These proved fairly satisfactory but, once they sank into the peat, draught was greatly increased by soil clogging up the spokes. Accordingly these wheels were further modified by converting them into cylindrical drums with 1/8 in. mild steel plates. These drums were 15 ins. wide, and 1½ ins. grousers were fitted every 17 ins. This modification proved very satisfactory although there was some tendency for the wheels to work loose. The extra load imposed on the axles introduced a possible source of trouble but none was experienced. On harder soil, however, there would probably be excessive wear on the wheel bearings.

Drilling was completed during the period 23rd to 29th July, 1948, the work proceeding at an average rate of 1 acre per hour. Dangerous, deep

holes were marked with posts beforehand and work proceeded steadily. The rear two gangs of the Martin disc-harrow were towed behind the drill and acted as an efficient covering harrow. Drilling details are given in Table II.

Table II.

Particulars of Mechanical Drilling and Sowing.

Block	Area acres	Spacing ins.	Drilling Depth ins.	Intended Seed Rate lbs.	Actual Seed Rate lbs.
A1	11	7	2	44	54
A2	17	14	2	44	38
B	*28	14	2	76	90

* Two acres in Block B could not be drilled owing to inadequate drainage.

In order to test the manurial distribution mechanism half of Block B was drilled with rock phosphate with the adjustment set for an application of 100 lbs. per acre. In practice only 60 lbs. per acre were applied, apparently because earth on the drill-wheels increased their effective diameter by as much as 4 ins.

Initial germination was excellent and very even, and the crop soon resembled a field of young wheat. There was some bird damage but the depth of drilling prevented extensive damage. However, when the crop was a few inches high and still too small to flood, very extensive damage was caused by mole-crickets; large patches would turn brown and wither almost overnight. There was also considerable damage by grasshoppers but on a less serious scale. Remedial measures taken were as follows:—

(a) Distribution of Agrocide 7-Bran bait.

(b) Dusting with 5 per cent. Agrocide 2-D.D.T. mixture.

(c) Re-drilling 10 to 12 acres of Block B with 15 lbs. per acre of the Agrocide-D.D.T. mixture.

(d) Flooding of the land to the greatest possible depth. This proved the best control method but killed off some of the later-drilled crop.

Subsequent growth was satisfactory but many vacant patches in Block B had to be supplied by hand-transplanting seedlings from thickly sown areas. At one time huge swarms of a Chrysomelid beetle (*Haltica* sp.) caused some concern but they appeared to do no harm at all and it was concluded that the destruction of their host plants (*Jussiaea* spp.) by cultivation had left them " in the air." A smaller incidence of the black padi bug (*Scotinophora coarctata*) was viewed with much greater concern and it was brought under control by widespread dusting with a 5 per cent. Agrocide 2-D.D.T. 50:50 mixture.

Subsequently *Scotinophora* re-appeared and the later attacks were never properly controlled, damage being severe wherever the water was shallow.

Early in December when the crop appeared to be vigorous it turned a sickly yellow colour which was more pronounced in Block A1 than elsewhere. This obvious nitrogen shortage was at first ascribed to the narrow drill-spacing. However, it was apparently caused by anaerobic conditions in the stagnant irrigation water because, after water withdrawal in early January, the crop immediately turned a healthy green and there was considerable production of late tillers which failed to form good ears.

Weed Growth and Control.

The following aquatic weeds, which were frequent in the surrounding hand-cultivated fields, appeared to have been killed by the well-spaced mechanical cultivations in dry conditions:—

Ipomoea reptans, Poir.
Utricularia flexuosa, Vahl.
Nymphaea sp.
Limnocharis flava, Buchenau.

About three weeks after sowing, when the ground surface was still dry, a vigorous growth of annuals sprang up on all but the wetter patches of land. The following four species were dominant, although many others occurred near the *batas*:—

Jussiaea linifolia, Vahl.
J. suffruticosa, Linn.
Ageratum conyzoides, Linn.
Physalis minima, Linn.

On the two sandy *permatang* lalang and other grasses were dominant. When the land was flooded both *Ageratum* and *Physalis* were killed and the *Jussiaea* spp. received a check.

The initial absence of sedges was most notable but, some two months after seeding, a vigorous crop of seedlings appeared wherever the padi crop was thin or patchy. The dominant species was *Fimbrostylis miliacea*, Vahl. and this appeared to be capable of germinating through shallow water.

A weed-control experiment was laid down on one of the drier portions of Block B and the following selective herbicides were tested:—

Y.F. 1541 (Fernoxone)	..	2, 4-D sodium salt.
Methoxone	..	4 chloro-2 methyl phenoxyacetic acid.
Barweed	..	2, 4-D amine.
Weedone	..	2, 4-D ethyl ester.

It would be out of place to discuss the results of this experiment in detail here but it may be noted that both the early application, 4 weeks after seeding, and the second application, 5 weeks later, were effective in killing off broad-leaved weeds. However, unless the land was subsequently flooded the treatment did not prevent germination of a second crop. When the first application was made the all-important sedges had not germinated. The late application proved to be ineffective in controlling them, although

individual plants suffered damage. Some hand-weeding proved essential and it was concluded that the only economical method of weed control was to aim at an even, closely-spaced padi crop with perfect water control. The latter requirement pre-supposes the existence of contour *batas* at vertical intervals of 6 to 12 ins.

Harvesting Trials, 1949.

The Combine-Harvester received in April, 1948, was still available for these trials and a 7 ft. McCormick Deering Rice Binder was received in February, 1949. For transport of the crop a 6 ton Athey track-trailer was also available.

The binder was modified by replacing the main pneumatic tyred wheel with a steel drum-wheel 14 ins. wide with a diameter of 33 ins. The grain wheel was replaced by a small Orolo track with a bearing area of 24 x 7 ins. Two small skids were fitted in front of and behind the main wheel but the front one was later removed.

The Combine-Harvester required further modification because, although the skid fitted in 1948 gave adequate flotation, the two wheels were ineffective and obviously had to be replaced by some form of tracks in order to reduce drag. These wheels and their stub-axles were accordingly removed and, a 3½ ins. diameter axle was fitted with spacing pieces to the existing main axle. Two track-assemblies were then made locally, each with three 2 ft. diameter drum-wheels, 12 ins. wide, spaced at 2 ft. intervals between centres. These wheels were fitted with 1½ ins. flanges in order to take a track made from a 14 ft. length of 12 ins. belting, to which 1½ x 1½ ins. angle-iron grousers were rivetted at 1 ft. intervals.

A stronger but heavier alternative to these home-made tracks became available late in March when a pair of large Orolo tracks, 14 ins. wide and 50 ins. long, were received. These two tracks were readily interchangeable.

The Athey track trailer was of very heavy construction, being designed for lumbering and the transport of heavy loads of sugar-cane. The two tracks were therefore detached and fitted to a light cart framework of *meranti* wood.

Harvesting operations commenced on 28th February, 1949, and were finally abandoned on 31st March. Work commenced in Block A1 with the binder and after 6 days work, covering 27 operating hours, about 6 acres had been reaped. The crop at first was not lodged and, although the straw was partly green, the grain was quite ripe by Malayan standards. There was standing water in many areas and the binder frequently became bogged down, whereas the tractor bearing-pressure was never a limiting factor. The small Orolo track worked well but the main drum-wheel tended to sink and jam in soft patches and to make ruts up to 1 ft. in depth. After rain these ruts formed puddles which delayed resumption of work. The actual mechanism of the Reaper-Binder was satisfactory; sheaves were well bound

PLATE IX.

Harvest in progress, 1949, showing the 7 ft. cut of the rice-binder.

PLATE X.

Rice-binder at harvest, drawn by a Caterpillar D.4. tractor.

PLATE XI.
Bogged down.

PLATE XII.
Closer view of the small Orolo track which replaced the grain-wheel of the binder.

and no trouble was experienced from broken twine. Occasionally there was some clogging at the extreme land-side of the platform but this was easily cleared.

Stooks were built with from 6 to 9 sheaves according to moisture content. This was easy when undertaken soon after reaping but the unripe straw soon softened and stooks which had to be moved one or more times soon presented an untidy appearance and grain shattered badly. The chief practical problem was to find sufficient dry land on which to build the stooks. Sometimes rain puddles formed and whole rows of stooks had to be removed to the drier edges of the field. An attempt was made to cap some of the stooks but this practice was abandoned after the first move.

Ripening and drying in the stook was most unsatisfactory. The weather was very hot and humid with occasional heavy rain-storms and no fresh drying winds were experienced. Frequently the larger stooks had to be re-built after rain because they were heating up inside.

There was only one light shower of rain during the first 5½ days work, after which 2.43 ins. fell in 36 hours. Subsequently heavy showers were experienced at intervals of 3 to 4 days so that the crop never again became dry enough to harvest. The total March rainfall at Chenderong Balai amounted to 11.03 ins. which was exceptionally heavy for the district. As a result of this unfavourable weather the Combine-Harvester could not be given a fair trial and no more work could be done with the binder.

The stook padi was threshed during the drier intervals using the Combine-Harvester with the sails removed. Some trouble was experienced with adjusting the threshing mechanism as the grain was very badly cracked. Finally, when the drum had been slowed right down and adjusted at the maximum distance from the concave, it was realized that the broken grain was caused by sun-cracking in the stooks. These cracks could easily be seen in the grain with a hand-lens and the damage was by then irreparable. It is difficult to see how this can be avoided except by threshing wet sheaves and thereafter drying the grain artificially. In practice the threshed grain was found to have a moisture content of 10.5 per cent. after having been 10 to 15 days in the stook.

Yields proved to be very disappointing, but shattering was so severe during movement of stooks that not too much importance should be placed on the figures. A reliable estimate by a Malay placed the yield at 200 to 250 gantangs per acre before harvest commenced. This, however, was an over-estimate both because of vacant patches in the crop and also because of the large proportion of late-formed tillers which failed to bear good ears. The crop would probably have given 120 to 150 gantangs per acre if harvested by hand, but it threshed out at less than 100 gantangs per acre. It should, however, be noted that the Malay cultivators themselves had considerable difficulty in reaping and drying their crops even by the normal hand methods.

Although the Combine-Harvester could not be tested on the crop it was put into the field in order to study the relative efficiency of the two types of track. The home-made tracks proved a disappointing failure; the bearing pressure was very low indeed and scarcely any impression was made when travelling over wet ground. However, the wet soil adhered to the drum-surfaces thereby nullifying the effect of the flanges and the belting tracks were forced off when turning.

The large Orolo tracks proved to be much heavier than was expected; each one weighed 850 lbs. and the machine's bearing pressure, with these fitted, was estimated at 3.8 lbs. per sq. in. It was more liable to bog down than the binder but the tracks ran freely and they did not form deep ruts. Unfortunately, by the time the tracks had been received and fitted heavy rain had lodged a large proportion of the crop which was, in any case, much too wet to harvest.

Costs.

The running costs of four mechanical cultivations and drilling amounted to $17.05 per acre. This figure included wages of operators, fuel and lubricant, and cost of seed. The overall cost of this work, including wages of store-keeper and of the miscellaneous hand-labour inseparable from experimental work, amounted to about $59 per acre. Neither figure includes depreciation on machinery because the unit is not an economic one. The higher figure is perhaps somewhat misleading as it is difficult to use labour economically when unsuitable or partially suitable machines are being tested.

No figures have been calculated for hand-weeding or for harvesting operations as these would serve no useful purpose.

Discussion.

It may be concluded from experimental work at Chenderong Balai that the mechanical cultivation of bog-soils is a practicable proposition once underground stumps and timbers have been removed. Initial cultivation must be planned to destroy the off-season weed-growth; thereafter production of a good seed-bed is simple. A 4-gang cut-away disc-harrow with discs spaced 9 ins. apart would appear to be the ideal implement for cultivation. Sowing can be carried out with a seed-drill; further work is desirable in order to determine the optimum method of irrigation after germination. If insect pests can be controlled it will probably be found that the fields should be kept quite dry for the first 4 or 5 weeks. However, the control of mole-crickets presents a problem which requires detailed study.

Trials with different types of tractors have produced some clear-cut results. Where a low bearing pressure is required it would seem that only track-tractors show promise. Tractors with outsize balloon wheels have not been tested but they are unlikely to have adequate power for traction on bog soils.

Two years experimenting with different types of track shoes has revealed that the most successful type is one which leaves the soil-crust intact. A grouser more than 2 ins. in height is undesirable and, under certain conditions, a flat wooden-faced track shoe is the most successful type. It will be possible to study this subject in more detail when a dynamometer becomes available.

It is not thought that greater efficiency can be obtained by increasing bearing area to give a lower ground pressure than 2.5 lbs. per sq. in. This is because the wider the track shoe the greater is the proportion of power absorbed in simple transmission, leaving less power for traction of implements.

Efficient weed-control is essential for healthy growth of padi. The four selective weed-killers have shown little promise since they have almost no effect on sedges. It is thought that the only sound method of reducing hand weeding is to have very efficient water-control and a close, even stand of padi. The former requirement assumes that contour *batas* or bunds can be made mechanically. The type considered desirable is a broad-based *batas* with gently sloping sides so that tractors and implements can pass over them without damage. It may be noted here that a "*batas*-maker" of partly American design is now under construction and this should be ready for the 1949-50 planting season.

It is interesting to note that, in California, the requirements of weed-control have dictated an almost complete change-over from drilling in the dry to broadcasting in water. Broadcasting is normally done from aircraft. This method requires investigation at Chenderong Balai, but a preliminary trial with broadcasting on wet peat gave very poor results and it is thought that the high proportion of organic matter may have inhibited germination in some way.

Mechanical harvesting trials to date have not been very successful but investigations will continue. Drainage of the fields was quite inadequate and the improvement of drainage is considered essential for progress and of greater importance than further modifications to harvesting machines.

In the past manurial experiments on padi in Malaya have rarely shown economic responses to any plant-nutrient. Peats and mucks present a fresh problem, however, because of the small percentage of mineral matter in the soil. A further complication arises from the ease with which stagnant water produces anaerobic conditions on peats, and the physiological disease known as *penyakit merah* is thought to be caused or at least encouraged by such conditions.

Acknowledgements.

This work has been greatly assisted by discussions with numerous other members of the Department of Agriculture and by advice from officers of the Drainage and Irrigation Department.

The solution of engineering problems and the execution of modifications have been facilitated by assistance, both in the workshop and field, from Messrs. D. Freer and D. F. Hunter of United Engineers Ltd.

The loan of certain American publications by Mr. W. O. Grut, General Manager of United Plantations Ltd., is gratefully acknowledged.

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THE FELLING AND DISPOSAL OF OLD OIL PALMS PRIOR TO REPLANTING

BY

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A large proportion of the present oil palm acreage was planted in the late twenties and early thirties and the palms have therefore reached or are nearing 20 years of age. Although the economic life of an oil palm is not known with any degree of certainty, the time will soon come when many of the earlier planted fields will require replanting.

Felling and disposal of old palms by hand presents some difficulty as the labour involved is very great. Mechanical or poisoning methods are obvious substitutes, and this article describes some methods which have been successfully tried at the Federal Experiment Station, Serdang.

There are two further points to be considered in the felling and disposal of oil palms. Firstly, it may be desirable to replant before the old palms are cut out and in this case the felling must be done in such a way that the young palms are not damaged. An experiment started on an estate in Selangor just before the war indicated that young palms could, with advantage, be planted at least a year before the old palms were removed.

Secondly, if it is intended to carry out regular inter-row mechanical cultivation of any kind, the old palms must be felled in such a way, and the young palms must be planted in such a position, that mechanical equipment can pass between the new rows without being obstructed by the old. This is clearly a somewhat difficult proposition.

Mechanical Methods of Felling.

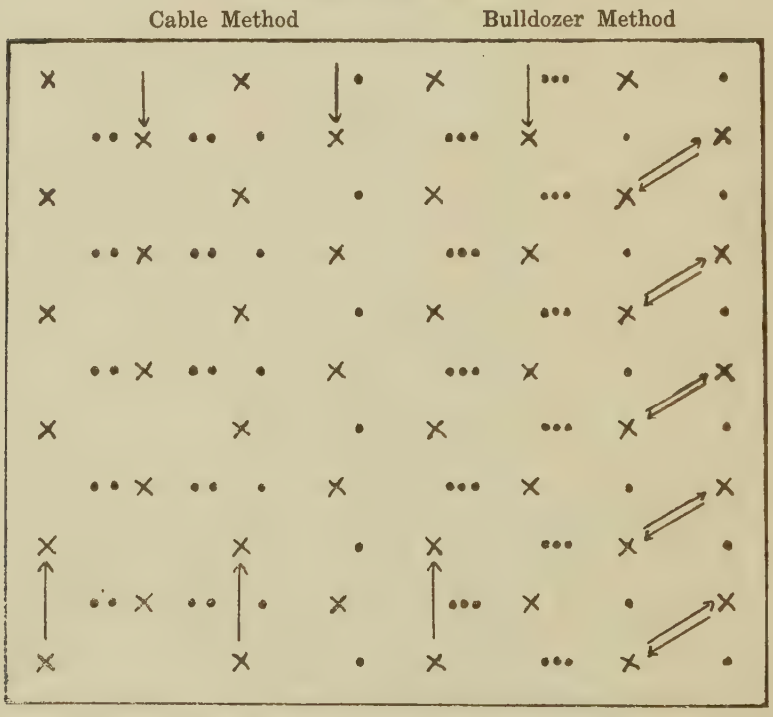
The oil palm is held in the ground extremely firmly by its roots and only the most powerful tractors can be successfully used for mechanical felling. At Serdang, in a valley quartzite sandy clay loam containing 40 to 50 per cent. fine fractions, it was noticed that during or at the end of the wet season the whole bole of the palm would emerge from the ground on falling, while at the end of the dry season the palm would often snap off at ground level. This fact, as will be seen, has some bearing on the value of the different methods employed.

With heavy tractors palms may either be pushed out of the ground by a bulldozer blade or they may be dragged over by a cable connected to the rear of two tractors which move forward on either side of a single or double row of palms. When a double row of palms is felled in one operation the palms fall inwards at an approximate angle of 45° to the line of motion and it was soon found that, with this method, the cable tended to ride up

more easily and slipped off the crowns of the palms before they were properly felled. There was a greater tendency for the cable to become entangled when this method was employed so that it was no quicker than the single row method and it was therefore not employed in later trials.

After preliminary trials in January 1948, opportunity was taken during August to compare the two methods of bulldozer and cable felling in two fields (Nos. 20B and 21) from which oil palms had to be removed. The palms were spaced at 30 ft. and 28 ft., triangular planting, respectively and were 22 to 24 years old. The work was carried out at the end of the dry season and about 3 acres were used for this comparison. Changkol handles were placed in various positions (see Diagrams I and II) to represent young palms and the number 'damaged' was recorded.

Mechanical Method of Felling Oil Palms.
Diagram I.
Portion of Field 20B.



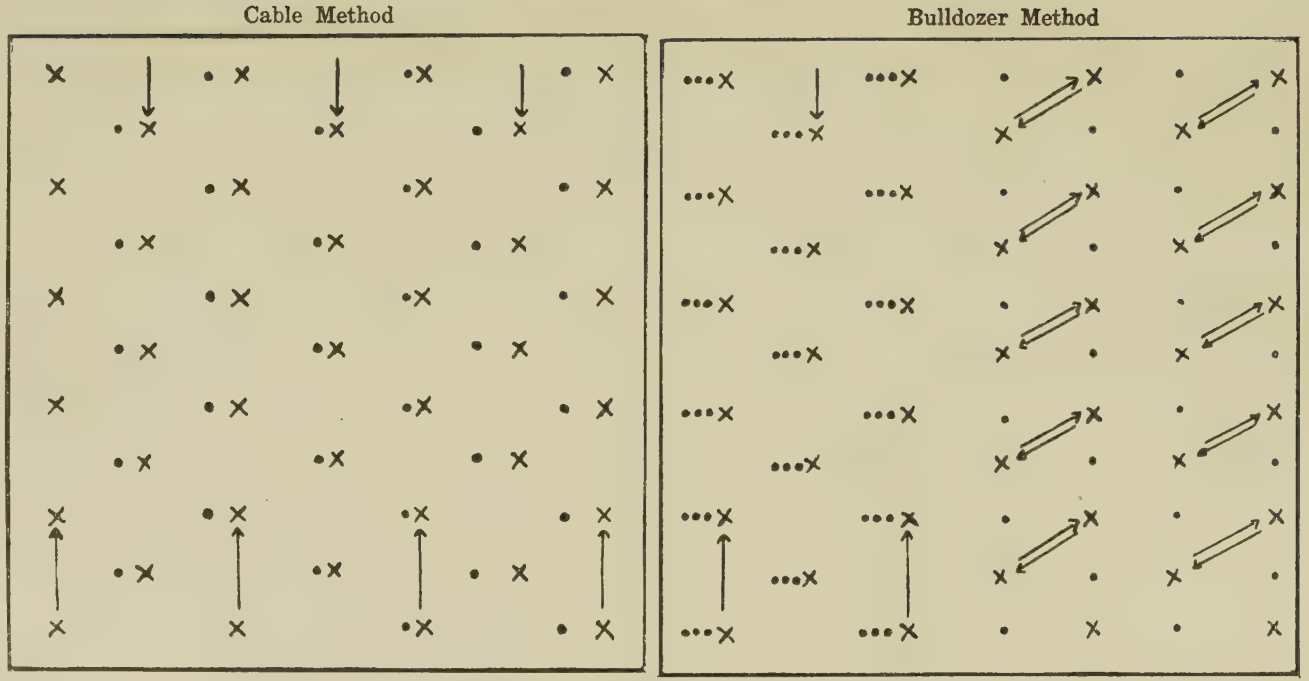
× = Old Oil Palm.
• = Position of 'Young Oil Palm'.
→ = Direction of Felling.
Scale 1 inch = 50 feet.

Table I summarises the results of these trials as far as time taken, fuel consumption etc. are concerned, while Table II shows the number of 'young palms' damaged. For the bulldozer method a Caterpillar D.8 (85 h.p.) tractor was used, while the tractors for the cable method were two Allis Chalmers H.D.10s (65 h.p.).

Mechanical Method of Felling Oil Palms.

Diagram II.

Portions of Field 21.



× = Old Oil Palm.
• = Position of 'Young Oil Palm'.
→ = Direction of Felling.
Scale 1 inch = 50 feet.

Table I.

Comparison of Oil Palm Felling Trials with Caterpillar D.8 and with 2 Allis Chalmers H.D.10s with Cable.

Field No.	Method	No. of palms felled	Time taken	Diesel fuel consumption			Labour employed				Total running cost	Running cost per acre*	Total cost per acre including depreciation, repairs etc.	Remarks
							Number		Cost					
				Total	Per hour	Total cost	Operators	Labourers	Operators	Labourers				
			mins.	galls.	galls.	$			$	$	$	$	$	
21	Cable ..	74	125	6	3	3.12	2	5	2.33	2.60	8.05	5.98	24.56	7 of the palms could not be felled by this method.
	Bulldozer ..	138	172	13	4½	6.76	1	1	1.61	0.72	9.09	3.62	15.05	Half the palms felled in straight lines. Half the palms felled 'head to tail'.
20B	Cable ..	69	83	4	3	2.08	2	5	1.55	1.73	5.36	4.27	18.03	—
	Bulldozer ..	67	63	5†	2½	2.60	1	1	0.59	0.26	3.45	2.83	11.45	Half the palms felled in straight lines. Half the palms felled 'head to tail'.

† Estimated figure; accurate measurement impossible owing to breakdown.

* Assuming 55 trees per acre.

Table II.

Comparison of 'Young Palms'* damaged by Cable and Bulldozer Methods of Felling.

Field No.	Method†	No. of old palms felled	Position of 'young palms' from rows of old palms	Number of 'young palms' damaged	Percentage damaged	Remarks
			ft.			
21	Cable ..	24	12	6	25	Young palms opposite old palms.
	-do- ..	27	8	8	30	-do-
	-do- ..	23	4	23	100	-do-
	Bulldozer 'head to tail'	68	between the palms within the row	nil	0	—
	Bulldozer 'straight lines'	70	8	nil	0	Young palms opposite old palms.
			6	nil	0	-do-
			4	nil	0	-do-
20B	Cable ..	33	17½	nil	0	Young palms opposite centre of space between old palms in one row, and opposite old palms in the other row.
			13	nil	0	
	-do- ..	36	4	36	100	Young palms opposite centre of space between old palms.
	Bulldozer 'head to tail'	34	between the palms within the row	nil	0	—
	Bulldozer 'straight lines'	31	8	nil	0	Young palms opposite centre of space between old palms.
			6	nil	0	-do-
			4	nil	0	-do-

* Represented by changkol handles.

† See Diagrams I and II.

It will be noted that depreciation and repairs constitute a very high proportion of the total costs, and clearly these methods would only be considered by contractors or firms operating on a very large scale. The method of calculation is that given on page 25 of the *Malayan Agricultural Journal* Volume XXXI, No. 1, 1948.

It will be noted that, as far as running costs are concerned, the bulldozing method appears to be the more efficient. The cable method, which is more spectacular and when operating well is undoubtedly very fast, has certain disadvantages. (See Plates I and II). Under Serdang conditions, when the soil was moist, a large proportion of the root system remained in the ground and the palm was not completely killed. Secondly, when the ground was dry and hard, the palm often snapped at ground level and in this case the cable, instead of slipping off the crown onto the trunk of the next palm, became entangled in the crown and began to drag the palm along, with the result that much time was wasted disentangling the cable. Thirdly, this method required a gang of labourers to handle the cable.

The bulldozing method (Plate III) was satisfactory except for the very largest and most firmly held palms. In this case a great deal of time was taken in working round the palm severing roots prior to felling. There is little doubt that felling even with a tractor of 85 h.p. is heavy work, and repairs, particularly to the clutch system, are likely to be required more frequently than usual.

As far as damage to young palms is concerned the bulldozing method is to be preferred. With a skilful operator it was found possible to fell a palm along the row without damage to a young palm set as close as 4 ft. from the row. With this system, regular mechanical cultivation could continue between the new rows except for a strip about 6 ft. wide containing the young plants and the old palms lying alongside them. Where mechanical cultivation is not envisaged the 'head to tail' method has much to recommend it and in this case it is easiest to plant the young palms within the old rows.

In the cable method, damage was often sustained by the " young palms " both from the cable itself and during the dragging of the old palms when they had snapped off at the base. It is not possible to plant the young palms close to the old rows when this method is to be used.

Disposal of Felled Palms.

Unsuccessful attempts have been made in the past to burn felled oil palms. When left in the field rotting takes place very slowly. It is unlikely that any estate would be able to afford much hand labour in disposing of palms after felling, but it is possible that cutting off the fronds and cutting the palms into lengths may hasten decay. Axes have been found to be more efficient than saws and no success has yet been attained with mechanical saws. After various combinations had been tried at

PLATE I.

Felling old oil palms with Allis Chalmers H.D.10s and cable.

PLATE II.

The bole of an old oil palm felled by cable at the end of the dry season.

PLATE III.

Felling with a Caterpillar D.8 and bulldozer.

Serdang it was found that a team of 3 axemen and 2 changkollers could deal with about 25 palms per day. The palms, felled by bulldozer, were cut up into three sections and the holes filled in by changkolling the earth back from the base of the palm into the hole. This work costs about $18 per acre.

Felling and Disposal by Poisoning.

A trial carried out at the Federal Experiment Station, Serdang, before the war showed that 4 ozs. of sodium arsenite per tree was sufficient to kill an oil palm. The method used was to bore four holes at equal distances around and near the base of the palm, place 1 oz. of sodium arsenite in each hole, add a small quantity of water and tamp the mouth of the hole with clay. The palm died within 3 weeks and gradually disintegrated. It was noted that the use of sodium arsenite did not prevent subsequent infestation by the Rhinoceros beetle.

A trial was started at Serdang in November, 1948, to see if smaller quantities of sodium arsenite could be used as effectively. Four groups of 8 palms were treated as follows:—

(1) *4 ozs.* Holes were bored by 1 in. auger around the circumference of the base of the palms, 1 oz. of powdered sodium arsenite was placed in each hole, water was added and the hole tamped with clay.

(2) *3 ozs.* As above, but 3 holes bored at an angle of 120° to each other.

(3) *2 ozs.* As above, but 2 holes bored opposite to each other.

(4) *1 oz.* As above, but one hole bored only.

Each hole was bored approximately as far as half the distance between the circumference and the centre of the palm.

From the beginning it was apparent that the palms treated with 1 oz. were almost as much affected as those which received 4 ozs. All palms showed signs of dying within a few days, and 10 days from treatment it was estimated that 70 to 80 per cent. of the fronds had withered. The rate of withering seemed to be slightly faster in the more heavily treated palms but one month after application the crowns of all palms were completely dead. From this time onwards the palms began gradually to collapse and disintegrate. Collapse of the trunks can take place at any point from near the ground to close to the crown. The first three trunks collapsed one month after treatment; of these two were in the 1 oz. plot and one was in the 2 oz. plot. Palms in the 3 oz. and 4 oz. plots did not begin to collapse until 7 weeks after treatment.

The position 6 months after treatment was as follows:—

Sodium arsenite per palm ozs.	Number of Palms			
	With leaves completely withered and drooping down	With crown fallen off	With trunk collapsed between the crown and the base	With trunk collapsed at the base
1	5	2	—	1
2	6	1	—	1
3	5	1	—	2
4	4	1	3	—
Total ..	20	5	3	4

Changkol handles to represent young palms were placed both between the rows and between the palms within the rows. When the palms collapse they usually buckle over. Young palms planted 15 ft. from the old ones are therefore unlikely to be seriously damaged and it was found that in practice they were only occasionally brushed by the dead fronds when an old palm collapsed.

Costs.

The disposal of palms by this method is quite cheap. Experience at Serdang and on a number of estates shows that between 30 and 50 auger holes can be made per day. Steel pipes hammered into the trunks have also been used, the rate of work being about the same as with the auger. With sodium arsenite at 36 cents per lb. and labour at $1.64 per day the cost per acre (55 palms) will be between $2 and $3.

Summary.

1. Felling and disposal of oil palms by mechanical and poisoning methods are described, and poisoning with sodium arsenite is shown to be the cheaper method.

2. In the poisoning method 1 oz. of sodium arsenite per tree is as effective as 2, 3 or 4 ozs. The cost of disposal of palms by this method is between $2 and $3 per acre.

3. Of the two mechanical methods tried, felling by bulldozer is to be preferred to felling by a cable drawn by two tractors. Heavy tractors are necessary, with consequent high cost of depreciation and repairs.

Acknowledgement.

Supervision of work in the field and the keeping of records in these trials were undertaken by Che Abu Bakar bin Ali Basha, Malay Agricultural Assistant.

FURTHER INVESTIGATIONS INTO THE MECHANICAL CLEARING OF FELLED RUBBER LANDS

BY

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Introduction.

The removal of rubber stumps on coastal clays by mechanical means was described in an earlier article(1). The present article deals with the work of clearing some 550 acres of land very similar to that described in the previous article except that there was little or no admixture of peat, and the secondary growths consisted of a tangled mass of *Melastoma malabathricum*, *Eupatorium odoratum* and various cover crops, with lalang and other grasses present but well suppressed by the heavy shade.

The method of clearing which was adopted is not necessarily considered to be the best but was dictated by the limited choice of implements available, the routine being: (1) slashing of the undergrowth, (2) burning, (3) stumping, (4) piling, and (5) rooting.

Slashing of the Undergrowth.

This is not an essential operation but was carried out in this case for safety reasons.

In view of the fact that we were not familiar with the land and could ill-afford to have any of the few heavy machines then at our disposal put out of commission even for a day or so, it was decided to slash the undergrowth before putting in the machine. In one part of a 450 acres block it was fortunate that this was done since the area was found to be honeycombed with old water wells dug by squatters during the early part of the Japanese regime.

This clearing was done by hand labour on contract at $25 per acre including burning. It is now considered, however, that this preliminary clearing is in general unnecessary, especially where the land is known to be safe. If there is any doubt a few inspection paths should be cut first and only dangerous areas completely slashed; in other areas D.8 and D.7 tractors can proceed with stumping.

Burning.

Burning enabled the cultivators to work more efficiently but cannot be recommended owing to the loss of valuable organic matter. It also has the added disadvantage of forcing any lalang growing in the area into flower within a period of about 3 weeks.

Two months after slashing and burning, about 75 per cent. of the area was covered with lalang; this had remained dormant under the *belukar* (secondary jungle growth) but with the clearing took on a new lease of life. If it is decided to burn, then there should be as little delay as possible before clearing commences otherwise the lalang obtains a strong hold and is much more difficult to eradicate.

Stumping.

The original planting on this estate was stated to be about 70 trees per acre. Of this number about 50 per cent. of the stumps were still hard and showed little sign of decomposition but the rest were in all stages of breaking down. The average diameter of the stumps was 18 ins. at 3 ft. above ground level.

The D.8 (135 h.p.) and D.7. (85 h.p.) tractors had no trouble at all in removing the stumps and it was found possible to run the machines straight up and down the rows taking the stumps in their stride. The cost of this work is given in Table I. Plate I shows the area after stumping.

Table I.

Costs of Stumping with D.8 or D.7 Tractors per day of 8 hours.

	$
1 Operator	5.00
1 Greaser	1.84
H.S.O. 30 gallons at 55 cts. less 5 per cent. Government discount ..	15.68
Cylinder oil ½ gallon at $2.18 per gallon	1.09
Petrol ¼ gallon at $1.35 per gallon	.17
Gear oil ¼ gallon at $2.12 per gallon	.26
Grease ¼ lb. at 28 cts. per lb.	.07
Depreciation (as estimated in *Malayan Agricultural Journal*, January 1948, page 24)	26.40
Repairs -do- -do- ..	26.40
Total cost per day	$76.91
Average number of acres completed per day	8 acres.
Approximate cost per acre	$9.61
Average number of stumps per acre = 70. Condition: between 50 to 70 per cent. half rotten.	

Stumping on land that is inclined to be wet and boggy becomes a difficult operation and is not to be recommended until the land becomes dry enough to enable D.7's or D.8's to work satisfactorily. It is not recommended trying to use D.4's since they have insufficient power. In neglected areas it is often necessary to clear and deepen all main drains before starting the stumping.

PLATE I.

An area after stumping.

PLATE II.

Forward-mounted root-rake on a D.8 "Caterpillar" tractor.

PLATE III.

Drag-type root-rake showing the three teeth.

PLATE IV.

Drag-type root-rake in action.

Removal and Piling of Stumps.

This operation is necessary in order to allow the cultivating implements a free run. During the operation of collecting the stumps into piles along the drain-edges, the machine also carried out a preliminary levelling of ant-hills, filling-in of wells, removing heavy *belukar* stumps, etc. This work was carried out partially by D.7's (85 h.p.) and partly by D.4's (49 h.p.) The D.7 is considered to be the better machine since heavy timber is inclined to overload the D.4. In addition a D.4 makes heavy going of levelling old and large ant hills.

The cost of this operation is exactly the same as for stumping, namely $9.61 per acre. It was found that approximately 8 acres could be dealt with in a day, the figure naturally varying quite appreciably depending upon the amount of timber that had to be piled and the levelling necessary. In piling, the heaps should be made as large as possible to facilitate burning and to reduce to a minimum their number per acre. If possible the heaps should also be sited on lalang-free ground since it has been found to be difficult to deal with this weed when growing amongst a pile of stumps.

Rooting.

In the earlier report(1) the necessity of removing lateral roots and buried timber was stressed. A root rake which is attached to a D.8 became available early in 1948 and is illustrated in Plate II.

It should be pointed out that normally the rake has 10 teeth but it was found that under normal dry land conditions the rake with its full complement of teeth failed to penetrate the ground. With half the teeth removed, fair penetration was obtained but the implement was never completely efficient.

To operate the root rake efficiently, considerable skill is necessary since in soft patches the rooter tended to go too deep and in dirty land to collect masses of weeds, both of which will eventually cause the D.7 or D.8 to stall. A good operator regulates this by continually lowering or raising the dozer blade. This naturally causes excessive wear on the power take-off cables and these had to be renewed at very short intervals.

Root raking performed two major roles: (1) removal of lateral roots to a depth of 9 ins. depending on hardness of ground, and (2) opening up of the land. It was also found that a considerable amount of lalang was brought to the surface by the rake and perished in dry weather. The chief objection to this form of rake is that the D.8 tracks consolidated the soil again and pushed much of the lalang back into the soil.

A drag-type of rooter was tried out during the latter part of clearing. In Plates III and IV it will be seen that the implement is a massive affair and needs a D.8 to pull it. Here again it was necessary to remove two of the teeth since, with the normal complement of five, penetration was poor and blocking by weeds very persistent and frequent. This frequent choking is the chief drawback to a drag implement as it necessitates frequent stop-

ping and backing of the power unit and the employment of a man on the implement to assist in clearing. Another objection is that a drag implement cannot get into corners and awkward places in the same way as the root rake but, on the other hand, it does have the great advantages that much better penetration is obtained and that depth of working can be controlled.

There is little or no difference in running costs between the two types. Neither approached complete efficiency under local conditions but preference should be given to the drag types.

It was found in practice that three labourers were required to finish off the work by collecting pieces of root, timber and stumps brought to the surface by the rakes, and throwing them on to the main piles. If these were not collected the harrows tended to become jammed and much time was wasted by the frequent stops which had to be made to clean the discs.

The cost of rooting is given below in Table II.

Table II.

Costs of Rooting with D.8 Tractor per day of 8 hours.

	$
As for D.8—Stumping	76.91
Plus wages of three labourers at $1.64 each	4.92
Depreciation of rake	2.00
Total cost per day	$83.83
Average acreage covered	8 acres.
Cost per acre	$10.48

There is considerable wear on the teeth of the rake. On the root rake it amounted to 4 ins. after completing approximately 600 acres.

Discussion.

Owing to the necessity for making the most of spells of weather suitable for mechanical cultivation it is often necessary in the tropics to work machines for as long as possible each day. This is a great strain on prime movers as well as on implements since maintenance has of necessity to be kept to a minimum. It was found that more time was wasted by repairs to implements than to prime movers. This is to be expected since the former generally received much less attention. For undertaking a major operation such as has been described the following recommendations are made:—

(1) Twenty per cent. of tractors and implements should always be in the workshop for maintenance and overhauls.

(2) No tractor or implement should be allowed to start work without a thorough inspection, and without being checked by a foreman or head mechanic.

(3) Track tractors are preferable to wheeled tractors for these operations.

(4) A full staff of mechanics and trained operators is essential. At least one trained mechanic for every two heavy machines should be provided. One operator per machine is sufficient. Spare drivers can be obtained by utilising trainees, who generally work as greasers, and from assistant mechanics. All operators should have some training as mechanics.

Acknowledgement.

This report has been written from notes and information given by Messrs. J. A. O. Beasley and R. J. Ewins, Food Production Officers, who were responsible for the clearing described.

Reference.

(1) Simpson, H. J. and Kendall, T. A. Investigations into Mechanical Stumping and Cultivation of Dry Padi on Felled Rubber Land. *Malayan Agricultural Journal*, Vol. XXXI, No. 1, January, 1948.

AN EXPERIMENT ON MECHANICAL METHODS OF LALANG ERADICATION

BY

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Areas under lalang in Malaya have greatly increased during the last 10 years. Not only have estates found that many areas of new planting reverted to lalang during the Japanese occupation, but large tracts of jungle country have been felled for tapioca and other foodcrops and, on their subsequent abandonment, have come under lalang.

The usual hand methods of eradication are now very expensive, $200 per acre being quite a normal contract rate, and in the re-opening of large areas from lalang other methods must be sought. Spraying with sodium arsenite has been successfully practised in many parts of the country and can usually be carried out for $70 to $100 per acre by hand-operated sprayers. Another article in this number describes certain methods of mechanical spraying and shows that costs can be much reduced. Nevertheless eradication by spraying is always likely to be a fairly expensive item owing to the quantity of sodium arsenite which must be used, and much interest has lately been shown, by those who are in a position to purchase machinery, in the eradication of lalang by tillage.

There are a number of different mechanical methods which could be carried out with the aid of medium or light tractors. These include the use of ploughs, disc-harrows, and rotary cultivators. It was decided early in 1948 to lay down an experiment at the Federal Experiment Station, Serdang, to compare the efficiency of mould-board and disc-ploughs, heavy disc-harrows and rotary cultivators when used for eradicating lalang. An area of exceptionally heavy sheet lalang in an exposed situation was chosen and marked off into strips of ½ chain width. The soil was transitional between hill quartzite and valley quartzite soils, but one corner of the field was rather low lying and boggy. The total length of each plot was 3¾ chains. All observations were carried out on the more uniform northern half of the area.

Owing to the necessity for accurate work on the land and the extra time that was necessarily taken in negotiating these narrow plots no attempt was made to assess costs of the various treatments from the work done in the experimental plots. Costs which are given in Tables V to VII are taken from other larger areas which have been cultivated by the same means. The experiment to be described was designed solely for the purpose of comparing the effects of the different cultivations on lalang growing on quartzite soil.

Lay-out and Treatment,

The experiment, which consisted of 3 randomised blocks, was designed to compare cultivation by:

A. Mould-board ploughing.

B. Disc-ploughing.

C. Disc-harrowing.

D. Rotary cultivation.

In the mould-board ploughed plots it was of course impossible to use a mould-board plough in the thick stand of sheet lalang. The top few inches of the soil and the growing lalang were first skimmed off by a preliminary disc-ploughing and subsequently all the resulting debris was turned in by a deep mould-board ploughing. In the disc-ploughed plots 2 ploughings to 10 ins. were given. In all the ploughed plots the clods, after they had been allowed to dry out, were harrowed down by 3 disc-harrowings at intervals of 2 to 2½ weeks.

Each plot was divided into 2 sub-plots:

(1) Control.

(2) Cultivation with a straight-tine cultivator.

The tine cultivation was given after all the main treatment cultivations had been completed.

Table I shows all the operations carried out on the plots. Subsequently half of each sub-plot was sown with a mixture of creeping covers. The growth of annual weeds was however very heavy both on the sown and unsown portions of the sub-plots and no differences were noted in the amount of lalang regeneration in the two halves. For the purpose of this article this further treatment is therefore being ignored.

Table I.

Cultivations Carried out on Plots under Four Main Treatments.

Date of Cultivation 1948	No. of Weeks from Initial Cultivation	Rainfall between each Cultivation ins.	A Mould-board Ploughing	B Disc-Ploughing	C Disc-Harrowing	D Rotary Cultivation
15th June	—	—	D.P. (S)	D.P.	D.H.	R.C.
25th June	1½	0.2	M.P.		D.H.	R.C.
16th July	4½	2.6		D.P.	D.H.	R.C.
10th Aug.	8	8.6	D.H.	D.H.	D.H.	R.C.
27th Aug.	10½	0.3	D.H.	D.H.	D.H.	R.C.
9th Sept.	12½	2.2	D.H.	D.H.	D.H.	R.C.
18th Sept.	13½	1.3	½ plots T.C.	½ plots T.C.	½ plots T.C.	½ plots T.C.

D.P. = disc-ploughing. M.P. = mould-board ploughing.
R.C. = rotary cultivation. T.C. = tine cultivation.
D.H. = disc-harrowing. (S) = shallow.

Equipment Used.

The equipment used was as follows:—

Treatment A. (Mould-board ploughing) ..	Caterpillar D.4 tractor and 3-furrow McCormick-Deering disc-plough (G.L. 70).
	Caterpillar D.4 tractor and single furrow 16 ins. "Prairie Buster" mould-board plough.
	Caterpillar D.4 tractor with heavy disc-harrows.
Treatment B. (Disc-ploughing) ..	Caterpillar D.4 tractor and 3-furrow McCormick-Deering disc-plough. (No. G.L. 70, 3-furrow, weight 2,467 lbs.).
	Caterpillar D.4 and heavy disc-harrows.
Treatment C. (Disc-harrowing) ..	Caterpillar D.4 and heavy disc-harrow (I.H. Dyrr offset F.T.). (Width 8½ ft., weight 2,285 lbs., 22 discs).
Treatment D. (Rotary cultivation) ..	Fordson Major tractor with rotary cultivator, (Howard Rotavator tractor attachment. Width 4 ft.).
Sub-plot Treatment 2. ..	Fordson Major and power-lift rear end tool bar with 7 tines attached giving a cultivating width of 6 ft.

Programme of Work.

The dry season of June to August 1948 was chosen for the work and the first cultivations were carried out on the 15th June. Plots A and B in each block were disc-ploughed, the latter to a depth of 10 ins. and the former to 2 to 3 ins. only as previously described. Plots C and D were disc-harrowed and rotary cultivated respectively. In plot C disc-harrowing was carried out twice, the first harrowing laying in the lalang and the second cutting into the soil to about 2 to 3 ins. The rotary cultivator in the D plots also covered the ground twice and had the effect of cutting the lalang off at ground level.

On 25th June the disc-harrow (Plate I) and rotary cultivation treatments were repeated with a single cultivation each. The disc-harrowing cut to 3 to 4 ins. depth and the Rotavator worked to a similar depth but there was much binding of the loose lalang round the drum of the Rotavator and this necessitated frequent stops. As pointed out later this difficulty can, however, to some extent be overcome. On plot A in each block the mould-board ploughing was carried out to a depth of 10 to 12 ins. In spite of the fact that the heavy lalang had been laid by the previous shallow disc-ploughing, considerable jamming of lalang leaves between the mould-board and the frame took place and the area was ploughed only with great difficulty. Experience in these plots shows that, however good the effect may be, mould-board ploughing cannot be a practicable proposition in areas of very heavy sheet lalang.

On 16th July a second disc-ploughing was carried out on the B plots. The clods from the first ploughing (Plate II) had remained exposed and undisturbed for 4½ weeks, during which time very little rain had fallen.

PLATE I.

Heavy disc-harrows at work on 26th June 1948, on one of the plots. Note the heavy sheet lalang on the right.

PLATE II.

A disc-ploughed plot 10 days after its first ploughing.

PLATE III.

A rotary cultivated plot after its final cultivation. Note withered lalang roots lying on the surface.

PLATE IV.

The same plot as in Plate III 2 months after the final cultivations.

This second ploughing merely had the effect of inverting the clods and breaking them up to a very limited extent. On the same day the third disc-harrowing and rotary cultivation were carried out on plots C and D respectively. In the disc-harrowed plots there was still a considerable amount of dried lalang on the surface and young lalang shoots were showing through. On the rotary cultivated plots the appearance was rather similar though the lalang which was still lying on the ground was more chopped up. Harrowing was carried out to 3 to 4 ins. without difficulty.

On 10th August the clods on all the ploughed plots were broken down by disc-harrowing and a fourth disc-harrowing and rotary cultivation were given to plots C and D respectively. In the rotary cultivated plots cultivation was carried out to a depth of 4 ins. without difficulty and by this time the soil was well pulverized and the lalang cut into small pieces. The lalang roots, which were now disentangled from the dry soil, were thrown into the air by the action of the Rotavator and, being light, came down to form a mat on the surface of the soil.

Observations on 18th August showed that on the mould-board and disc-ploughed plots (A and B) there were masses of withered lalang roots on top of and in the surface soil but there was no sprouting. On the disc-harrowed plots there was still a considerable amount of lalang leaves on the top of the soil which in some places appeared to have prevented the discs from biting fully into the soil. On the rotary cultivated plots there were quantities of short lengths of lalang roots, mostly withered and lying on the surface of the soil. No lalang shoots were appearing and the leaves had largely decomposed.

On 27th August and 9th September further disc-harrowings were given to plots A, B and C and further rotary cultivations (Plate III) to plots D. Before these treatments were given it was noticeable that there was a considerable quantity of lalang shoots in the disc-harrowed plots, particularly in Block 2, but fewer shoots in the rotary cultivated plots and fewer still in the ploughed plots.

Tine Cultivation.

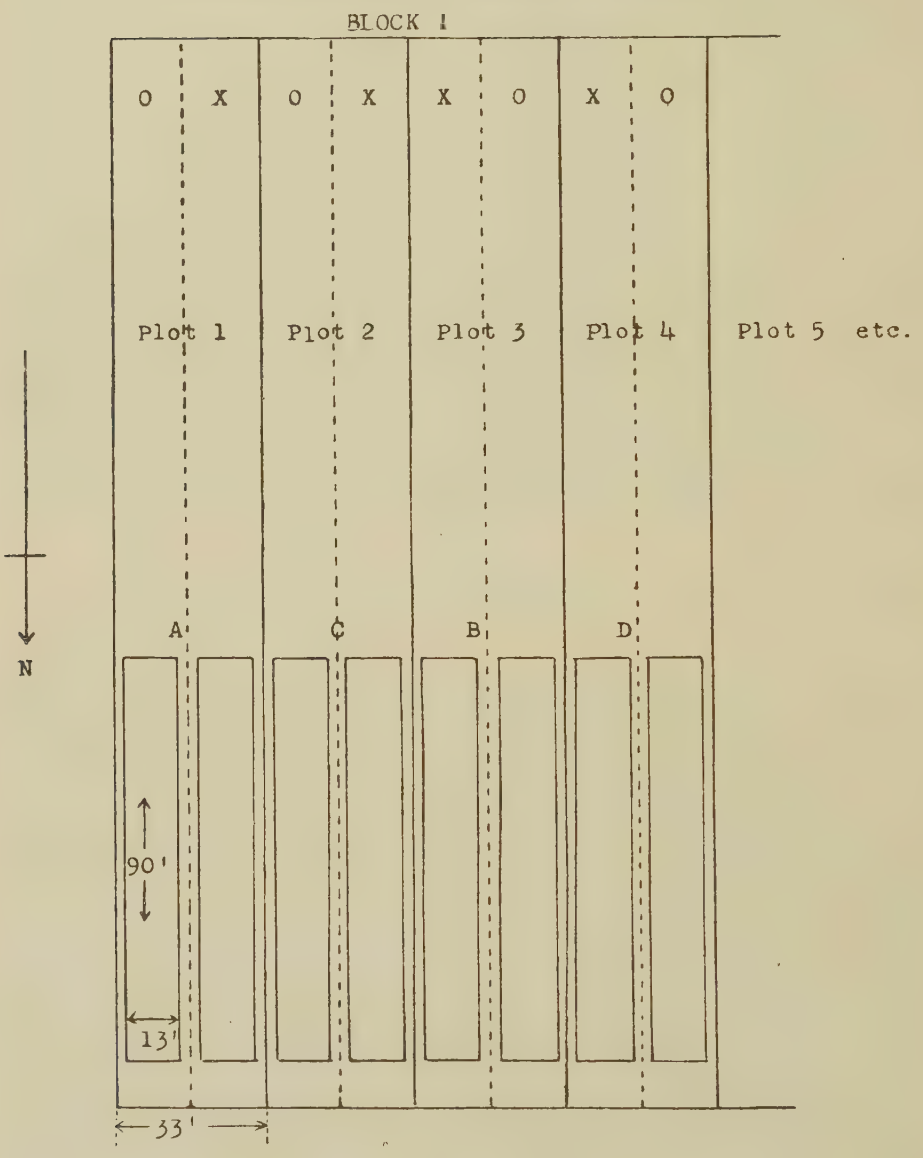
The sub-plot treatment was carried out on 18th September with a straight-tine cultivator attached to a Fordson Major. The cultivator used was a power-lift rear end tool bar normally carrying 9 strong tines, but in this case 2 outside tines were removed giving an overall width of 6 ft. It ran easily in all plots except in the disc-harrowed plots where large quantities of dried leaves and long lalang roots collected in front of the tines and had to be removed. Observations at the time of this treatment showed that there was very little sprouting in any of the plots except the disc-harrowed plots.

Post Treatment Observations and Records.

It was decided to assess the effectiveness of the treatments given by carrying out lalang shoot counts and later by recording the cost of digging

Figure I.

Mechanical Lalang Eradication Experiment.



Main Plots
- A = mould-board ploughing.
- B = disc-ploughing.
- C = disc-harrowing.
- D = rotary cultivation.

Sub-plots.
- O = control.
- X = cultivator.

out any lalang which grew back within the plots. No lalang eradication method is completely effective, and the employment of labour to fork out sporadic shoots a few months after the final treatment (whether it be digging or spraying) is usual practice. It was thought, therefore, that the amount of subsequent digging which was required would also give a good measure of the effectiveness of the treatments. The area was left for 8 weeks during which time the wet weather set in and 21.6 ins. of rain fell, of which only 2.12 ins. fell in the first 2 weeks and only 8.65 ins. in the first 4 weeks.

On 13th November a count was made of lalang shoots appearing in the plots. Figure 1 gives a plan of one block and shows the areas on which these counts were made. Dicards of 2 ft. between sub-plots and 5 ft. between plots were left and the actual area per sub-plot in which the count was made measured 90 x 13 ft.

The results of this count are given in Table II. Although the number of shoots in the ploughed plots was considerably less than in the harrowed and rotary cultivated plots the difference was not, however, significant. The use of the straight-tine cultivator had, however, significantly reduced the number of shoots, and in fact the number of shoots appearing in the cultivated sub-plots was only half the number appearing in the uncultivated sub-plots. A further count was carried out 4 weeks later on 11th December with the purpose of ascertaining whether further shoots were appearing. The figures given in Table III show that in fact less shoots were recorded in the second count than in the first. There are a number of possible explanations for this. In the first place the cover crops and annual weeds made rapid growth during November (Plate IV), and many of the very weak lalang shoots which were appearing at the beginning of November were probably crowded out by this heavy growth. Secondly the accuracy of the recorder's work was probably somewhat reduced by the presence of this heavy weed growth. The total number of lalang shoots on the ploughed plots was still much less than on the harrowed and rotary cultivated plots, though this difference is again not significant. The difference between the number of shoots in the cultivated and non-cultivated sub-plots was even greater than before.

These results and subsequent observations on the area showed that there was a greater lack of uniformity than was apparent when the area was under a heavy growth of lalang. Sub-plot treatments, being only two, were in adjacent long narrow sub-plots and in the first count the non-cultivated sub-plots gave a smaller number of shoots than the cultivated sub-plots in only 2 out of 12 comparisons. The difference between sub-plot treatments was therefore significant. In the comparison between main plot treatments, however, the order of merit was quite different in each block and by the time the experiment was completed it was apparent that the position of the individual plots had been an important factor. Plots on the

Table II.

Number of Lalang Shoots per Sub-Plot of 1,170 sq. ft. on 13th November, 1948, 8 weeks after Final Cultivation.

Block No.	Mould-board Plough			Disc-Plough			Disc-Harrow			Rotary Cultivator			Total		Total
		Tine Cultivation	No Tine Cultivation		Tine Cultivation	No Tine Cultivation		Tine Cultivation	No Tine Cultivation		Tine Cultivation	No Tine Cultivation	Tine Cultivation	No Tine Cultivation	
Block I ..	(1)	10	17	(3)	39	189	(2)	54	87	(4)	169	483	272	776	1,048
Block II ..	(5)	86	273	(7)	48	44	(8)	416	293	(6)	178	356	728	966	1,694
Block III ..	(10)	56	138	(9)	26	145	(12)	13	61	(11)	12	61	107	405	512
Total ..		152	428		113	378		483	441		359	900	1,107	2,147	
		580			491			924			1,259		3,254		

Note.—Figures in brackets indicate the plot number.

Table III.

Shoot Count on 11th December 1948, 12 weeks after Final Cultivation.

Block I ..	3	9	17	86	32	52	141	388	193	535	728
Block II ..	40	161	23	32	206	204	128	284	397	681	1,078
Block III ..	29	59	14	66	10	80	20	58	73	263	336
Total ..	72	229	54	184	248	336	289	730	663	1,479	
	301		238		584		1,019		2,142		

two extremities of the area (and particularly in Block I) were lowest lying and the heavy rain which followed the completion of cultivation caused these plots to become soggy and undoubtedly inhibited lalang growth. From observation throughout the period of cultivation and after it is thought that the results obtained from plot 3 to plot 10 inclusive gave a reasonably true picture of the comparative effects of the main treatments and gave a strong indication that ploughing was more effective than harrowing or rotary cultivation.

Digging of sporadic lalang was not undertaken until nearly 4 months (16 weeks) after the final cultivation treatments. The method used was to allot one man to each block so that no difference of efficiency between the men would affect the within block comparisons. The men worked at a normal pace throughout and recordings were made of the time taken to dig sporadic lalang: (a) in the 90 ft. strips in which the shoot counts had been made, (b) in the remaining strips of the sub-plots, and (c) in the guard strips or discards. Table IV shows the cost of digging in the strips in which shoot counts had been made. These costs were calculated on a basis of 7½ hours actual work at a wage of $1.64 per day. Over the total area, including the non-counted strips and the discards, digging costs were $12.55 or just under $6 per acre.

It will be noted that the use of the straight-tine cultivator has reduced costs by 50 per cent. This reduction is statistically significant though the differences between main treatments, though considerable, are again not significant.

Further diggings of sporadic shoots were carried out at the 5th and 6th month after final cultivation. The work involved was so small that no assessment was made of the cost of each plot. At the fifth month the overall cost per acre was 83 cents and at the sixth month $1.23. It was then considered that the field was fit for handing over to the ordinary sporadic lalang patrol.

Costs.

It was mentioned earlier in this article that the costs of the work done on the experiment plots were not calculated owing to the fact that these plots were too small to give representative figures. Costs have, however, been obtained from work done on larger areas on similar fields at the Federal Experiment Station, Serdang, and these are given below. Figures for mould-board ploughing are not given since work with mould-board ploughs in lalang areas has been found to be very slow, with frequent stoppages for clearing the plough, and their use is clearly not a practical proposition except perhaps in level areas which have been burnt over or otherwise cleared of vegetation.

Disc-Ploughing.

The costs of carrying out, on an area of 13 acres, the same succession of operations as was carried out in the experiment is given in Table V.

Table IV.

Cost of Digging Sporadic Lalang Shoots 4 months after Cultivation.

	A Mould-board Ploughing		B Disc-Ploughing		C Disc-Harrowing		D Rotary Cultivation		Total		Total
	Tine Cultivation	No Tine Cultivation	Tine Cultivation	No Tine Cultivation	Tine Cultivation	No Tine Cultivation	Tine Cultivation	No Tine Cultivation	Tine Cultivation	No Tine Cultivation	
(1) Cost per Sub-Plot of 1,170 sq. ft. ..	cents	cents	cents	cents	cents	cents	cents	cents	cents	cents	cents
Block I ..	1.5	8.0	6.6	21.9	8.8	16.0	20.8	51.4	37.7	97.3	135.0
Block II ..	20.0	14.2	5.5	3.6	47.7	55.4	22.2	48.1	95.4	121.3	216.7
Block III ..	8.4	12.0	6.2	17.1	3.3	12.4	2.6	10.6	20.5	52.1	72.6
Total ..	29.9	34.2	18.3	42.6	59.8	83.8	45.6	110.1	153.6	270.7	424.3
Total ..	64.1		60.9		143.6		155.7		424.3		
	$	$	$	$	$	$	$	$	$	$	
(2) Total Cost per acre ..	3.70	4.24	2.27	5.28	7.41	10.39	5.65	13.65	4.76	8.39	
Mean ..	3.97		3.78		8.90		9.65				

Table V.

Costs of Disc-Ploughing followed by Heavy Disc-Harrowing and Straight-Tine Cultivation in Field 10b.

Tractor	Implement	Acres	Hours Worked	Fuel: Petrol galls.	Fuel: Diesel or T.V.O. § galls.	Cylinder Oil and Lubricants galls.	Total Running Costs* $	Running Costs per hour $	Running Costs per acre $	Total Costs per acre† $
Caterpillar D.4	3-furrow disc-plough ..	12.6	36	3½	51	2	65.84	1.83	5.23	13.80
-do- ..	-do- ..	12.9	29	3	43	2½	56.27	1.94	4.36	11.18
-do- ..	Heavy disc-harrow ..	12.9	19½	1	27	¾	33.38	1.71	2.59	7.14
-do- ..	-do- ..	12.9	11	1	15	¾	20.01	1.82	1.55	4.11
-do- ..	-do- ..	12.9	10	¾	14	½	17.78	1.78	1.38	3.71
Total ..									15.11	39.94
Fordson tine cultivation ..		12.9	10	1	12½	—	19.83	1.98	1.54	2.14
Total with tine cultivation ..									16.65	42.08

* Based on the use of 1 operator and 1 labourer at total cost of 81 cents per hour, and on fuel at the following prices per gallon: petrol $1.36, T.V.O. $0.83, diesel $0.54, cylinder oil $2.19.

† Including an estimate of depreciation and repairs.

§ T.V.O. = Tractor vaporising oil.

Disc-Harrowing.

A good estimate of the cost of eradication by disc-harrowing by 6 discings as was done in the experiment is obtained from operations carried out in mixed lalang and *belukar* (secondary jungle growth) in an oil palm area at Serdang in which the actual area of ground cultivated was 10.9 acres. Details are given in Table VI.

Costs of eradication by disc-ploughing and disc-harrowing could be reduced by using a tractor of rather lower horse power. For disc-harrowing heavy harrows are, however, essential and a crawler type of tractor is therefore more suitable for this work. A test was recently carried out at Serdang using a Caterpillar D.2 tractor (25 h.p.) with a Rome 'disc-ploughing' cut-away disc-harrow weighing 3,360 lbs. working in mixed grasses (including lalang) and *belukar* to a height of 10 to 12 ft. This combination covered 1 acre in 1 hour 40 minutes, with running costs $2.38 per acre. For a test on already cultivated land 1 acre was covered in 35 minutes with running costs at 85 cents per acre. With an estimate of depreciation and repair costs added, therefore, it is reasonable to assume that sheet lalang eradication could be carried out for about $8 to $10 per acre for the first double harrowing and $2 to $2.50 each for 5 further single harrowings, giving a total cost of about $20 to $25 per acre.

Rotary Cultivation.

There has been some difficulty at Serdang in carrying out costing tests with conditions comparable to those of the experiment owing to lack of suitable lalang areas. The estimate given in Table VII is based on: (1) the mean of two tests on two small areas of ¼ acre each in which tall sheet lalang was rotary cultivated using (a) steel wheels and (b) rubber wheels, and (2) a test of rotary cultivating ½ acre of land which had been cultivated for the first time 3 weeks previously.

Discussion.

This experiment has shown that it is possible to eradicate lalang quite cheaply with the use of disc-ploughs, heavy disc-harrows and large rotary cultivators and that the additional use of a straight-tine cultivator as a last operation increases the completeness of the eradication.

It must be borne in mind that this experiment was carried out on inland quartzite soil carrying heavy lalang in a fully exposed situation. It is pertinent to ask how far these results can be applied to other soils and other situations. Lalang thrives best under conditions of full sunlight and is suppressed by shade; therefore it may be expected that less cultivation would be required for eradication under, say, the partial shade of coconuts and oil palms. This has indeed been the experience on a number of estates where these methods have been employed. On one estate employing a rotary cultivator and Fordson tractor, 3 or 4 runs were found sufficient to eradicate lalang in areas of mixed lalang and *belukar*. Similarly reduced work has been successful with disc-harrows.

Table VI. Estimates of Costs of Lalang Eradication by Disc-Harrowing.

Tractor	Implement	Acres per hour	Fuel per hour			Running Costs		Total Costs	
			Diesel galls.	Petrol galls.	Cylinder Oil and Lubricants galls.	per hour $	per acre $	per hour $	per acre $
Caterpillar D.4	heavy disc-harrow (double discing)	0.46	1.6	0.1	0.05	1.92	4.27	4.92	10.70
-do-	5 single discings each estimated at	1.00	1.4	0.1	0.05	1.82	1.82	4.82	4.82
Total of 1 double and 5 single discings			..	..	..	..	..	13.37	34.80
Fordson tine cultivation			..	..	..	..	..	1.54	2.14
Total with tine cultivation			..	..	..	..	..	14.91	36.94

Table VII. Estimate of Cost of Eradicating Lalang by Rotary Cultivation.

Cultivation	Acres per hour	Fuel per hour			Running Costs		Total Costs	
		T.V.O. galls.	Petrol galls.	Cylinder Oil and Lubricants galls.	per hour $	per acre $	per hour $	per acre $
(1) Initial cultivation ..	0.48	2.1	0.1	0.05	2.80	5.83	4.30	8.96
Double cultivation ..					5.40	11.66	8.60	17.92
(2) 5 single cultivations each estimated at. ..	0.64	2.4	0.1	0.05	3.05	4.76	4.55	7.11
Total of 1 double and 5 single cultivations		..	..	..	..	..	35.46	53.47
Fordson tine cultivation ..		..	..	..	..	..	1.54	2.14
Total with tine cultivation		..	..	..	..	..	37.00	55.61

With regard to other soils, experience has shown that these methods can be as successfully employed on coastal clays as on inland soils, and indeed it is on coastal soils that mechanical methods are more likely to find favour in comparison with spraying. In the first place, in many inland areas the topography makes the use of tractors difficult and sometimes impossible, and there is danger of soil erosion. Secondly, spraying has on the whole been found less successful (in completeness of eradication) on coastal clays than on inland soils. Nevertheless mechanical cultivation has already been used on a large scale on inland soils and with considerable success.

With regard to costs it will be noted that, with disc-ploughs and heavy harrows, costs can be very low if care is taken to use a tractor suited to the implements. Unfortunately only Caterpillar D.4 tractors were available for the experiment but the use of lower horse power crawlers such as the Caterpillar D.2 or the International Harvester T.D.6 would have reduced the costs considerably, and they are more suitable unless the work is to be done in a situation where 6- to 10-furrow disc-ploughs or several heavy disc-harrows can be hitched to the tractor. In many situations in Malaya, and particularly when working in a tree crop plantation, only single harrows or small ploughs can be conveniently used.

Rotary cultivation with a Fordson and Rotavator attachment was more expensive than disc-harrowing or ploughing with crawler tractors using diesel oil. Fuel consumption was rather heavy. Costs of rotary cultivation have been found to vary very widely, however, and there is little doubt that this combination is a sound method of eradication; moreover it can with advantage be combined with the use of the straight-tine cultivator using the same tractor. On one coconut estate over 300 acres of mixed lalang and *belukar* have been eradicated for an overall cost of about $45 per acre. There is little danger of wheel-slip with this implement (the cultivator blades revolve in the same direction as the wheels) so that rubber tyres can be used. It can indeed be said that this is the only mechanical cultivation for which rubber wheeled tractors can at present be recommended under Malayan conditions. In practice the rate of work per day varies very greatly according to the weather and type of vegetation. In heavy sheet lalang the binding of leaves round the drum may be a great source of trouble, and on one estate this was to some extent overcome by routine clearing of vegetation with a curved knife at the end of every run up and down the field. Later cultivations present very little trouble of this kind.

Eradication by Combined Spraying and Mechanical Cultivation.

Some planters have been interested in the possibility of eradication by spraying followed by mechanical cultivation or vice-versa. Sodium arsenite kills lalang by its action on the leaves and stems, and on theoretical grounds it would be expected that greater effect would be obtained by

Table VIII.

Spraying and Rotary Cultivation on Two Sets of Plots.

Date 1949	BLOCK I.				BLOCK II.				Rain
	Spraying First		Rotary Cultivation First		Spraying First		Rotary Cultivation First		
	Spray	R.C.	R.C.	Spray	Spray	R.C.	R.C.	Spray	
13th Jan. ..	ABCD	—	—	—	—	—	—	—	O
22nd Jan. ..	ABCD	—	—	—	—	—	—	—	O
2nd Feb. ..	CD	AB	EFGH	—	ABCD	—	EFGH	—	O
9th Feb. ..	CD	—	—	—	ABCD	—	—	—	O
16th Feb. ..	—	ABCD	EFGH	—	CD	AB	EFGH	—	R
23rd Feb. ..	—	—	—	—	CD	—	—	—	R
2nd March ..	—	BCD	FH	—	—	ABCD	FH	—	O
9th March ..	—	—	—	EG	—	—	—	EG	R
16th March ..	—	BD	FH	EG	—	BCD	FH	EG	O
23rd March ..	—	—	—	G	—	—	—	G	R
30th March ..	—	D	—	G	—	BD	—	G	R
6th April ..	—	—	—	FH	—	—	—	FH	R
13th April ..	—	—	—	FH	—	D	—	FH	R
20th April ..	—	—	—	H	—	—	—	H	R
27th April ..	—	—	—	H	—	—	—	H	O
	4	5	4	8	4	5	4	8	

A = 2S—2R
B = 2S—4R
C = 4S—2R
D = 4S—4R
E = 2R—2S
F = 4R—2S
G = 2R—4S
H = 4R—4S

O = no rain for 24 hours after spraying, ignoring quantities less than 0.1 in.
R = rain within 24 hours of spraying.

spraying before rather than after cultivation. Moreover in spraying after cultivation a great deal of the spray would inevitably fall not on the young shoots but on the bare ground where it would be wasted. These ideas were put to the test in a small trial on some patches of sheet lalang in two fields at Serdang adjoining the area on which the previously described experiment had been carried out.

Two sets of plots of 1/40th acre were treated as follows:—

Designation	Treatment
A. 2S—2R	2 sprayings at weekly intervals followed by 2 rotary cultivations at fortnightly intervals.
B. 2S—4R	2 sprayings at weekly intervals followed by 4 rotary cultivations at fortnightly intervals.
C. 4S—2R	4 sprayings at weekly intervals followed by 2 rotary cultivations at fortnightly intervals.
D. 4S—4R	4 sprayings at weekly intervals followed by 4 rotary cultivations at fortnightly intervals.
E. 2R—2S	2 rotary cultivations at fortnightly intervals followed by 2 sprayings at weekly intervals.
F. 4R—2S	4 rotary cultivations at fortnightly intervals followed by 2 sprayings at weekly intervals.
G. 2R—4S	2 rotary cultivations at fortnightly intervals followed by 4 sprayings at weekly intervals.
H. 4R—4S	4 rotary cultivations at fortnightly intervals followed by 4 sprayings at weekly intervals.

Table VIII shows the dates on which these operations were carried out. It will be noted that the interval between the last spraying and first rotary cultivations was only a week, while the interval between the last rotary cultivations and first sprayings was 3 weeks, since it was necessary to allow the lalang to shoot before spraying could be undertaken.

It will be seen that there is a bias in favour of plots A, B, C and D in Block I and plots A and B in Block II in that no rain fell after any of their sprayings. Comparison of the effects of treatments C and D with treatments G and H in Block II is, however, in general conformity with other comparisons and it is therefore not considered that this bias is very great. Moreover there is a bias in favour of plots F and H which were sprayed after cultivation since operations on these plots were the last to be completed and there was less time for regeneration of lalang before the assessment of regrowth was carried out. Regrowth of lalang was assessed three weeks after the final spraying by four independent scorers. During this period there was frequent though not very heavy rain. The scale used was as follows:—

1 } Lalang absent or almost absent.
2 }

3 } Lalang present only as occasional shoots.
4 }

5 } Lalang plentiful but sporadic.
6 }

7 } Lalang frequent over whole plot.
8 }

9 } Lalang dominant.
10 }

The means of the scores obtained were as follows:—

Treatment	Block I	Block II	Mean
A. 2S—2R	7.75	8.75	8.25
B. 2S—4R	1.50	2.50	2.00
C. 4S—2R	7.00	5.75	6.38
D. 4S—4R	2.75	1.25	2.00
		Mean	4.66
E. 2R—2S	10.00	10.00	10.00
F. 4R—2S	5.75	3.75	4.75
G. 2R—4S	8.75	7.75	8.25
H. 4R—4S	3.25	5.25	4.25
		Mean	6.81

It will be noted that in each case where the same number of cultivations and sprayings have been given, less lalang has regenerated when the sprayings have been done first. Four sprayings before cultivation have shown no advantage over 2 sprayings and it appears that effective control has been obtained where 4 rotary cultivations have followed 2 or 4 sprayings Four rotary cultivations seem to have been the dominant means of eradication throughout.

Summary.

1. An experiment has been described in which heavy sheet lalang on inland quartzite soil in an exposed situation was successfully eradicated by disc and mould-board ploughs, heavy disc-harrows, and a rotary cultivator.

2. Though no significant differences were shown between these four treatments there was an indication that ploughing was more consistently effective than disc-harrowing or rotary cultivation.

3. A final cultivation with a straight-tine cultivator significantly reduced the amount of lalang which survived.

4. Lalang which survived the treatments was dug out at a cost varying from only $2.27 per acre (disc-ploughing and tine cultivation) to $13.65 per acre (rotary cultivation without tine cultivation).

5. Costs of mechanical cultivation varied from $34.80 to $55.61 per acre but it was shown that with suitable tractors and implements eradication could be carried out for costs as low as $20 to $25 per acre (including depreciation etc.).

6. The application of these results to other soils and other situations is discussed.

7. In a small trial in which eradication of lalang was attempted with varying numbers of weekly sprayings with sodium arsenite and varying

numbers of cultivations with a rotary cultivator, it was shown that spraying before cultivation was more effective than cultivation before spraying. Effective control was obtained with 2 sprayings followed by 4 rotary cultivations.

Acknowledgements.

Acknowledgement is made to Che Hashim Shah bin Mohd. Shah, Agricultural Assistant, who was responsible for keeping the experimental records; to Mr. H. D. Matheson, Agricultural Officer, who organised the work on the spraying and cultivation trial; to the lecturers and students of the College of Agriculture who undertook the lalang shoot counts; and to a number of planters with whom I have had discussions at various times and particularly to Mr. J. L. Goddard who has provided much useful information on rotary cultivation of lalang and *belukar* areas.

MECHANICAL SPRAYING FOR THE ERADICATION OF LALANG

BY

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Areas of lalang in Malaya increased considerably during and after the war and eradication by hand means is expensive. The use of sodium arsenite with hand-operated sprayers has been a common practice throughout the country but reduction in costs can be effected by the use of mechanical sprayers; this article describes various types which have been used at the Federal Experiment Station, Serdang. Several types of spraying machinery have been received at this Station during the past two years, the majority of the sprayers being attached to light horticultural tractors and not primarily designed for the rather severe task of lalang spraying. They have nevertheless been used with considerable success.

Effective control of lalang has been obtained by using sodium arsenite in 1.6 per cent. solution applied at the rate of 10 lbs. of arsenite or 60 gallons of solution per acre in each of 10 applications.(1). It was assumed in the trials described that this quantity of liquid should be applied and no attempt has been made to spray higher concentrations with low volume sprayers.

The Allen Motor Scythe Spraying Attachment.

The first spraying machine used was the spraying attachment to the Allen motor scythe. This small tractor, powered by a 1.5 h.p. engine, is supplied with a direct displacement pump in addition to the grass-cutting knife. The pump is attached to the front of the machine and is protected by a flat plate which slides over the ground. As no liquid container was supplied, one was improvised from a 4 gallon petrol tin which was slung between the handlebars at the rear of the tractor. This arrangement was only partially satisfactory since when the tank was full, the tractor tended to tilt backwards, and, in addition, the clearance between the bottom of the tank and the ground was so small that manoeuvrability was seriously impaired. It is understood that an overhead mounted tank can now be obtained for this machine, an arrangement which would be more satisfactory.

In spite of these difficulties, however, very useful results were obtained, both in light sporadic and heavy sheet lalang. In light lalang it was found unnecessary to cut rentices, and the method employed was to run the machine along a line, spraying to a distance of 15 ft. on one side of the line and then to return along the same line spraying on the other side. In this way one small strip about 4 ft. wide was flattened for

every 30 ft. width sprayed. Spraying was carried out with the tractor in motion.

With heavy sheet lalang it was essential to cut and trample rentices through the grass before the tractor could proceed, and, even so, difficulty was experienced owing to the low position of the spray tank. However it was possible to spray more or less continuously, following the same method as for light lalang. The supply of water for the machine requires careful organisation. The tank capacity was only 4 gallons, and using a 1/16 in. nozzle on the lance the tank was emptied in 5 minutes, which necessitated frequent stops for refilling; even with 40 gallon drums of water spaced throughout the area, two labourers were required to maintain adequate supply of water to the machine. Doubling of the tank capacity would reduce this difficulty, but it is considered unlikely that this small machine would be able to draw much more than 10 to 15 gallons of liquid over the rather uneven ground which is common in lalang areas.

The men required to keep this machine in operation were: 1 operator, ($1.84 per day), 1 lance holder ($1.64 per day), and 2 water carriers ($3.28 per day). In a test, 0.52 acre was covered in 65 minutes (approximately ½ acre per hour). Costs per acre for spraying sheet lalang (6½ hours per day in actual operation) were calculated to be:—

	$
Labour	2.06
Fuel (4 pints petrol)	0.68
Depreciation and repairs	0.90
	$3.64

Solution sprayed per acre—approximately 60 gallons.

This little machine has been found very useful on estates for eradicating patches of light lalang in rubber areas. Under these conditions, provided the water supply is well organised, a much higher acreage can be covered and it is considered that this machine is most suited to this type of work.

The Gravely Tractor with Spraying Attachment.

The Gravely tractor has as one of its attachments a 40 gallon tank mounted on rubber tyres and fitted with its own Hardie direct displacement pump, belt-driven from the tractor engine, and with a single spraying lance. This unit is solidly constructed and it was decided to test the machine for lalang spraying. As with the Allen motor scythe, it was found necessary to make rentices through heavy lalang before the tractor could make reasonable progress. With the tank full to capacity the tractor was difficult to manoeuvre. An attempt was made to spray with the tractor in motion, but this led to stretching of the belt drive between tractor and pump unit, and finally to slipping of the belt. Subsequently spraying was done only

when the tractor was stationary. With a tank of 40 gallons capacity less time was required for filling than with the Allen. The spray lance fitted to the machine was of a very useful, adjustable type with which a very close spray or a rather coarser jet could be produced while spraying was actually in progress. It was found that, moving up the flattened rentices, a strip 30 ft. wide on either side could be sprayed effectively, using a pressure of between 150 to 200 lbs. per sq. in. The labour force required to keep the machine in operation consisted of 1 operator, ($1.84 per day), 1 lance holder, ($1.64 per day), and 2 water carriers, ($3.28 per day). In a test, 11.1 acres were sprayed in 14 hours (0.79 acre per hour). Costs per acre (6½ hours per day in actual operation) were calculated to be:—

	$
Labour	1.37
Fuel (4½ pints petrol)	0.77
Depreciation and repairs	0.80
	$2.94

Solution sprayed per acre—approximately 60 gallons.

This machine is not suitable for use on slopes where manoeuvring would be at all difficult.

Modifications of the Gravely Spraying Attachment for use with a Bristol 10 h.p. Tractor.

Some time after commencing work with the Gravely tractor and its spraying attachment it was decided to modify the tank and pump slightly so that they could be attached to the more powerful Bristol, a 10 h.p. crawler-tractor. It was hoped to overcome the difficulties experienced with the Gravely, i.e. the heaviness and lack of manoeuvrability. The pump was removed from the tank and mounted on a small platform which was constructed at the rear of the Bristol, the pump then being driven by the power take-off of this tractor. The tank was fitted with a drawbar and attached behind the tractor, and the various hose connexions then made secure.

This arrangement was very satisfactory, the Bristol having sufficient power to negotiate heavy lalang areas with no previous renticing and in addition, being on tracks, was able to cover fairly rough and sloping land with little difficulty. The positive drive to the pump ensured a constant pressure at all times.

The team used with this modified combination consisted of an operator, ($3.42 per day), a lance holder, ($1.64 per day), and two water carriers, ($3.28 per day). The spraying was done in an oil palm area planted 30 x 30 ft. triangular, and the tractor moved up a line of palms spraying the avenue on either side. In a test, 6.7 acres were sprayed in 5 hours (1.34 acres per hour). The pump delivered at a constant pressure

of 150 lbs. per sq. in. Costs per acre (6½ hours per day in actual operation) was calculated to be:—

		$
Labour		0.90
Fuel	petrol 2 pints	0.34
	*T.V.O. 2.6 pints	0.29
Depreciation and repairs		0.75
		$2.28

Solution sprayed per acre—approximately 60 gallons.

It was obvious while working the Bristol with the spraying attachment and only one lance, that the pump was delivering far more than the controlled 150 lbs. per sq. in. pressure, and the by-pass valve was in constant use. Efforts were therefore made to obtain another lance of the same pattern as the one in use, it being considered that with two lances the rate of work could be increased to nearly 2 acres per hour with consequent reduction of working costs to less than $2 per acre. Unfortunately it was impossible to purchase a lance of the required type locally. This combination has been found to be the most successful one for work in areas where the stand of lalang is uneven and in patches, and where it is unnecessary to spray evenly over the whole area.

Boom Spraying.

For use in even areas of sheet lalang it was decided to modify the spraying unit still further by fitting a 200 ins. spraying boom behind the tank. Much work has been done in the United States in determining the optimum nozzle size, angle of spray etc. for sprayers of various types. It has been found that twin 80° fan nozzles, 40 ins. apart inclined at an angle of 65° to each other, at a height of 18 ins. above the ground give the most even distribution of liquid.(2)

Five twin 80° fan nozzles were purchased locally and inserted at 40 ins. intervals in ½ in. galvanised iron water piping. The piping was divided into two lengths and hinged so that it could be raised vertically for ease of travelling. Intake pipes from the ends of the two lengths were connected to the pump by rubber pressure hose. The height above ground of the nozzles was 2 ft. and the boom could be raised still further for very tall lalang. This modification was highly successful.

The team required to keep the sprayer in constant operation consisted of 1 operator ($3.42 per day), and 2 water carriers ($3.28 per day). In a test, 1.71 acres were sprayed in 77 minutes (1.33 acres per hour). The operator had some difficulty, when on the return trips, in determining exactly where the area just sprayed terminated, but with the help of one of the

* T.V.O. = Tractor vaporising oil.

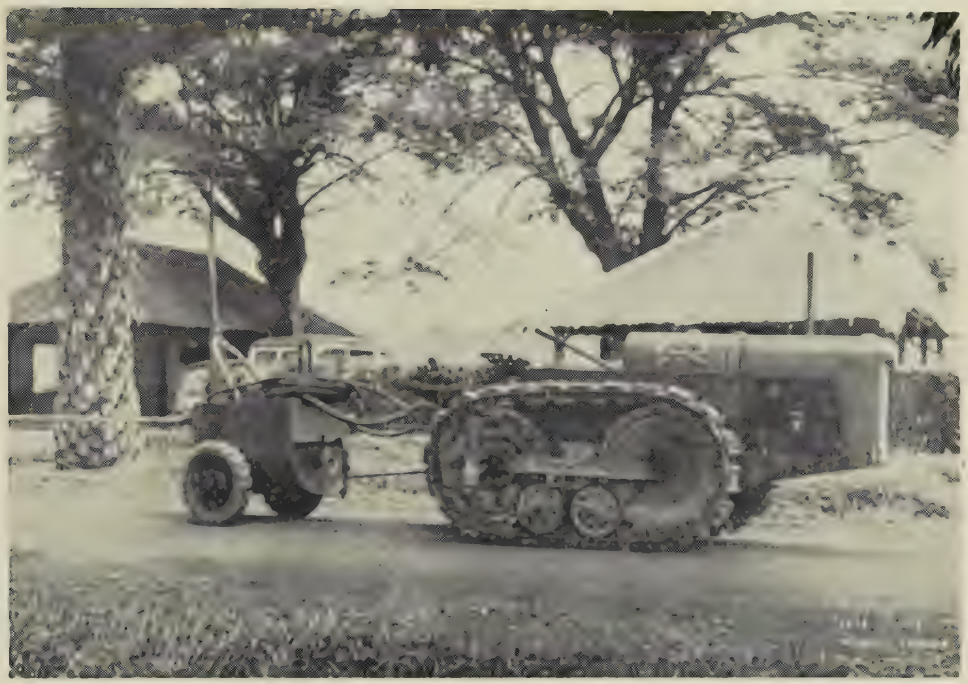

PLATE I.
The modified Gravely spraying attachment and the Bristol tractor.

PLATE II.
The Gravely spraying attachment.

water-carrying labourers, who marked with a pole the edge of the sprayed area at the end of the runs, he was able to avoid all but a little overlapping. Running with the tractor in bottom gear (approximately 10 to 15 m.p.h.) it was found that the 40 gallons of liquid contained in the tank were exhausted in 12 to 15 minutes, refilling taking about 5 minutes. Costs per acre (6½ hours per day in actual operation) were:—

		$
Labour		0.76
Fuel	petrol ¾ pint	0.13
	T.V.O. 2.3 pints	0.24
Depreciation and repairs		0.75
		$1.88

Solution sprayed per acre at 50 lbs. per sq. in.—approximately 60 gallons.

The amount of liquid sprayed per acre can be reduced by lowering the working pressure or by increasing the travelling speed by engaging a higher gear. In spite of the acreage covered per hour being the same as that covered with the lance sprayer, costs were reduced owing partly to the fact that one labourer less was required. It was also noticed that the continuous running resulted in the consumption of a lower proportion of petrol to T.V.O. than was the case with the more variable speeds in the lance spraying. (This tractor has bi-fuel carburation).

Further improvements are now under consideration for this equipment. The tank capacity is much too small for the boom and for the tractor's power. It is considered that a tank with a capacity of about 200 gallons mounted on a wider wheelbase would be more satisfactory, and that the tractor is easily capable of towing such a tank. With this arrangement much less time would be taken in filling, and with large tanks of water spaced at convenient intervals across the area to be sprayed, one of the water-carrying labourers could be dispensed with. In this way, costs, including depreciation, could probably be reduced to $1.50 per acre or less.

Other Types of Sprayers.

The only other sprayer tried at Serdang has been the attachment for the Auto-Culto light tractor. Although this is excellent for spraying fruit trees it was found quite unsuitable for use in lalang areas owing to the high rate of travel and consequent difficulty in manoeuvring. Mention should however be made of the use of compressors and booms attached to Fordson tractors which have been successfully used on some estates.

Discussion.

Table I gives details of the rate of work and costs with the various tractors. From an inspection of the figures it will be noticed that with

Table I.

Rate of Work and Costs of Spraying by Four Different Methods at the Federal Experiment Station, Serdang.

Tractor and Sprayer	Horse-power	Acreage per hour	Gallons sprayed per acre	Costs per Acre				Cost of 10 spraying including 100 lbs. sodium arsenite	Remarks
				Labour $	Fuel $	Depreciation and Repairs $	Total $	$	
Allen motor scythe and spraying attachment ..	1.5	0.50	60	2.06	0.68	0.90	3.64	70.40	Costs do not include cutting of rentices.
Gravely tractor with spraying attachment	5.0	0.79	60	1.37	0.77	0.80	2.94	63.40	-do-
Bristol tractor with Hardie pump and tank (from Gravely tractor) ..	10.0	1.34	60	0.90	0.63	0.75	2.28	56.80	Using one lance only.
Bristol with 200 ins. boom sprayer ..	10.0	1.33	90	0.76	0.37	0.75	1.88	52.80*	Boom fitted with 5 twin 80° fan nozzles. * (assuming 10 lbs. sodium arsenite per spraying).

Notes—(1) In the case of the Allen and the Gravely tractors, operators have been charged at $1.84 per 8 hour day of which it is estimated that 6½ hours will be spent in actual operation in the field, 1½ hours being allowed for maintenance, minor adjustments, travelling to and from the field etc. With the Bristol, operators have been charged at $3.42 per day.

(2) Depreciation and repairs have been estimated in accordance with the system outlined in the *Malayan Agricultural Journal*, Vol. XXXI, No. 1, page 23, January, 1948.

the smallest of the tractors the cost of the normal 10 sprayings plus the cost of 100 lbs. of sodium arsenite ($34) is $70 per acre, which is little, if any, lower than with hand spraying, and is only slightly quicker. With the more expensive Bristol tractor and boom, costs can be reduced to $53 per acre and the rate of work considerably increased. It is likely that the cost of eradicating lalang by spraying with sodium arsenite will always be more expensive than by mechanical cultivation, unless the price of sodium arsenite falls very considerably. There are, however, many areas in which, for one reason or another, it is impracticable or undesirable to use mechanical cultivation for the eradication of lalang, and in such areas equipment such as that described above could result in a considerable saving over hand methods of spraying.

Summary.

Costs of spraying sodium arsenite solution for the eradication of lalang can be reduced by the use of mechanical sprayers.

Both light sprayers attached to horticultural tractors and lance and boom sprayers attached to a light crawler-tractor have been used, and in the latter case total spraying costs have been reduced to the equivalent to $53 per acre for a full 10 sprayings.

Acknowledgements.

We have to acknowledge the assistance we have had from records left by Mr. P. G. Coleman, Agricultural Officer, Penang and Province Wellesley, and from information supplied by Mr. E. F. Allen, Agricultural Officer, Perak South.

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MECHANICAL PLUCKING OF TEA WITH THE "TARPEN TRIMMER"

BY

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The history of modern methods of hand-plucking of tea dates from 1855. Previous to this, the maximum crop was about 200 lbs. of made tea per acre per year. Experiments were therefore undertaken by the early pioneers of the tea industry in Ceylon and India to find out the best methods of plucking the flush with a view to increasing the crop and at the same time maintaining the quality of made tea and the vigour of the bush. The results of these trials showed that increases in crop and quality depended on the method of plucking.

The methods of plucking the flush can roughly be described under three headings, namely "Fine", "Medium" and "Coarse". Fine plucking is limited to a leaf bud, one leaf just below it and the top half of the third leaf, leaving behind on the growing shoot at least two fully developed leaves above the undeveloped leaf which is known as the "fish leaf". Tea plucked in this way, consisting only of immature flush, gives a tea of good appearance but contains less tannin on which the strength, colour and pungency of the liquors depend. Further, fine plucking reduces the yield of crop and if continued for long periods often leads to "sulking" or "shutting up" of the bush.

Coarse plucking consists of picking a leaf bud and three or more leaves below it on the growing shoot. This method of picking causes a strain on the bush and gives tea of low quality and poor appearance.

Medium plucking consists of picking a leaf bud and the two leaves below it. This method leaves behind on the bush a number of immature shoots which assist in the process of photosynthesis. The flush collected in this manner gives tea of good appearance and quality, and the maximum yields are maintained. The quality also depends on how long the flush is allowed to grow between plucking rounds.

It is clear that the adoption of mechanical plucking will lead to the plucking of some shoots 'light', some 'medium', and some 'coarse', since the plucking surface of the bush carries shoots of varying ages which have grown to different heights.

Description of the "Tarpen Trimmer" Mechanical Plucker.

The unit consists of an electric generating set, producing 110 volts, and four trimmers which are designed to operate simultaneously. The trimmers are made on the lines of a mechanical hedge trimmer and are connected by long insulated cables to four separate sockets on the generator.

The Tarpen Trimmer.

Tea plucking with the Tarpon Trimmer.

Tea plucking with the Tarpon Trimmer.

Each trimmer is operated by a labourer, and the plucked leaves are swept into a tray by a driven paddle-wheel. The capacity of each tray is 1½ to 2 lbs. of green leaves. The trimmer (with tray) weighs 10 lbs. and is slung from the operator's shoulders. (See Plates).

The whole generating unit is mounted on a low metal frame supported by two small, solid rubber-tyred wheels.

Fuel Consumption.

The unit requires about 1 gallon of petrol and ¼ pint of lubricating oil for 8 hours working.

Experiment.

A trial was commenced in November, 1948, to pluck tea leaves with the "Tarpen Trimmer". Two plots with an even stand of tea bushes, each plot carrying a total of 1,600 bushes, were selected; the bushes were planted 4 x 4ft. square. The tea flush in one plot was plucked mechanically, and in the other plot by hand in the usual way. The harvesting of the flush in both plots was at uniform intervals, and in order to bring both the plots to uniform intervals of harvesting the first three rounds of flush were collected by the different methods and discarded.

Table I gives the results of harvestings.

Table I.

Green Leaf per Plot of 1,600 Bushes Harvested Mechanically and by Hand, Costs of Harvesting, and Hours Worked.

	Mechanical Plucking			Hand Plucking		
	Yield lbs.	Costs $	Man & Boy hours worked	Yield lbs.	Costs $	Women hours worked
1948						
23rd Nov.	147	7.66	27½	98	2.85	15
2nd Dec.	92	8.70	32½	94	2.85	15
13th Dec.	106	10.42	40	117	2.85	15
22nd Dec.	116	10.42	40	77	4.75	25
1949						
4th Jan.	52	10.97	40	128	4.56	24
17th Jan.	57	10.46	40	119	3.99	21
26th Jan.	70	7.98	30	68	3.04	16
4th Feb.	16	5.51	20	73	3.42	18
21st Feb.	74	9.21	35	183	9.41	49½
5th Mar.	114	7.97	30	194	5.23	27½
17th Mar.	63	7.10	26	174	4.66	24½
31st Mar.	70	8.14	30	82	2.85	15
9th Apr.	51	9.18	35	139	3.99	21
25th Apr.	229	10.78	40	278	6.65	35
Totals ..	1,257	124.50	466	1,824	61.10	321½

Cost per lb. of green flush, hand plucked 3.3 cents.

-do- mechanically plucked 9.9 cents.

Labour and Costs.

Women labourers employed for hand plucking were paid $1.32 per 7 hour day. Men labourers were employed for mechanical harvesting; one operator, three men at $1.64 each, and one boy at $1.32 per working day of 7 hours. In the above table the operator is costed at $1.84 which is the present wage of a motor cultivator driver. Actually a tractor operator on a considerably higher wage was used for the work but normally a motor cultivator driver would be employed. In the trial only three trimmers were used, although the unit could take four trimmers. An additional trimmer was not provided by the local agents of this unit. Had four trimmers been available the cost per lb. would probably have been just under 8 cents.

Results.

(i) It will be seen from the harvesting records that the yield of flush was higher in the hand picked plots (1,824 lbs.) than from the mechanically harvested plot (1,257 lbs.). It is suggested that the unselective plucking of the trimmer is responsible for considerable loss of crop because of the damage done to the immature flush. Yields began to fall at the 5th plucking.

(ii) The cost of harvesting by hand was 3.3 cents per lb., whereas the lowest estimate of mechanical plucking with four trimmers was just under 8 cents per lb. It should be noted that the latter figure does not include depreciation.

(iii) The made tea from the mechanically harvested plot was inferior in quality. Furthermore, a higher proportion of red stems and over-matured leaves was present.

(iv) The transport and handling of the unit in the field were found difficult on account of the small wheels and considerable weight (334 lbs.).

(v) The number of man and boy days required for plucking 1,257 lbs. of green leaf was actually greater than the number of women days for hand plucking 1,824 lbs.

Discussion.

From the above results and observations it appears that the use of this unit is not economical and practicable under the prevailing wage rates and system of planting tea in Malaya. It is considered that the planting of tea in hedges would be more suitable for mechanical harvesting.

In order to make the plucking machine less expensive to run, it appears that it might be modified considerably. Firstly, the machine could be more easily transportable in order to reduce the time taken in moving it from place to place.

One disadvantage of the machine that is not likely to be overcome is that the quality of the made tea is poor. In monsoon countries, however, where the flush is more dependent on the season, it is possible that a mechanical plucker could be used with better results because the fibre

develops later. The made tea, therefore, would not be so seriously affected by mechanical plucking. In such countries, moreover, a proportion of the labour is only required seasonally. Therefore, if the machine could be so modified as to require less labour to pluck a given quantity of tea than by hand plucking it might be of great use, since seasonal labour is usually hard to get.

Heavier manurial dressings may be necessary in order to maintain the vigour of the bushes which are to be mechanically plucked, because some of the immature flush is always cut at the same time as the mature flush, thus reducing the area of leaf available for photosynthesis.

In a recent article(1) it was stated that mechanical pluckers are being experimented with at the Tea Research Institute at Tocklai. The results of the first trials in Assam indicate that the mechanical plucker which had been tried there was considered to have several defects and to be far from satisfactory. The main criticism of the machine itself was that the blade was much too short (only 1 ft.) with the result that the saving of time and labour was not so great as might be expected. This is certainly in conformity with experience of the machine in the trial just described. It is believed in Assam that in the first year little more than 50 per cent. of the maximum possible crop will be harvested, though this loss of crop is expected to be much less in the second and third years. A promising future for such a machine is envisaged only if it can be made to operate with a long blade which can straddle the bushes planted in a hedge and can be made to move quickly down the hedge, cutting as it goes. It is thought that only by some such means can sufficient labour be saved to justify its use.

Reference.

(1) Kingdon-Ward, F. Tea and New Processes. *The Planters Chronicle*, Vol. XLIV, No. 9, May, 1949.

NOTES ON SOME LIGHT TRACTORS ON TRIAL AT THE FEDERAL EXPERIMENT STATION, SERDANG

BY

G. S. KEEPING,
Agricultural Officer, (Research).

During the past few months extensive trials have been undertaken with various types of light horticultural tractors, and the results of these trials are summarized below.

Barford " Atom."

The smallest tractor received by the Department; it has been used extensively for grass cutting for which it is very suitable. It is supplied with an electric hedge-trimming attachment, with its own generating set, which has proved useful for clipping bamboo hedges. Other implements received with the tractor include disc-harrows and hoes, but these are very light and hardly suitable for Malayan conditions. The machine supplied was fitted with a single central steel wheel, but later models have twin wheels. A rotary lawn mower is now also available, an attachment which should prove very useful. The engine is rated at 1 h.p.

Allen Motor Scythe.

A small tractor, designed primarily for grass cutting and spraying, although further implements have now been designed for it. It is manoeuvrable and light to handle, and is powered by a 1.5 h.p. two stroke engine. It has been found very suitable for both grass cutting and spraying work; this latter aspect is dealt with more fully in another article of this issue.

Lloyds Autosickle.

This small machine is designed for grass cutting only and for that purpose is cheap and economical to operate. It is capable of cutting over fairly rough ground, but the actuating mechanism to the reciprocating knife blade is liable to breakage. This mechanism has recently been modified slightly on one machine with promising results.

Montgomery Ward Garden Tractor.

This machine is one of the lightest horticultural tractors received, but it has nevertheless proved itself very useful, and is exceptionally economical to run. It is light and manoeuvrable, an important point in two-wheeled tractors where the operator walks behind and steers. As supplied it was fitted with a plough, and had, in addition, a set of disc-harrows and a light cultivator. Being rated at 3.2 h.p. it is capable of working well under light conditions only, but for nursery or market garden

PLATE I.
Lloyds Autosickle.

PLATE II.
Montgomery Ward tractor with disc-harrows attached.

PLATE III.
Clifford rotary cultivator.

PLATE IV.
Gravely tractor with cutter bar.

use where soil conditions are suitable it is a useful machine. The cultivator is lightly constructed and of limited use.

Waterloo " 30 " Horticultural Tractor.

A Canadian made machine similar in all respects to the Montgomery Ward and with a similar performance. It was supplied with the same implements as the Montgomery Ward, but had in addition a rotary type power-driven lawn mower which was capable of cutting grass very close at quite a good speed.

Autoculto Horticultural Tractor.

Of 3.6 h.p. this machine is powered by a two-stroke engine. It is supplied with plough, cultivators, roller and spraying equipment. Of the implements only the spraying equipment has been tested to date; it appeared satisfactory for the spraying of fruit trees, although not so for sheet lalang. Details of the spraying work can be found in another article of this issue.

Clifford Rotary Cultivator.

A machine of similar design to the Gem rotary hoe, it is powered by a 4.5 h.p. engine, and runs on T.V.O. (tractor vaporising oil). It is rather slower than the Gem, but is capable of producing an excellent tilth under suitable conditions. It is supplied also with hoeing and ridging attachments, which are very effective for row crop cultivation.

Gravely Horticultural Tractor.

An American machine having a 5 h.p. engine and supplied with a wide range of implements, the majority of which, however, are insufficiently robust and of limited use under Malayan conditions. The disc-harrows, for example, have as bearings two shaped pieces of soft wood held together by metal straps, while the plough has no coulter or screw depth adjustment. The cutter-bar, however, is well made, and the machine fitted with the attachment is capable of dealing with heavy growths of tall grass, lalang and weeds, with ample power in reserve. Being fitted with reverse gears, the machine is simple to manoeuvre in confined spaces. The spraying unit supplied consisted of a 40 gallon tank mounted on rubber wheels, and attached directly to the tractor, with a positive displacement type pump driven from the tractor engine. This unit is simple to operate, and very suitable for the spraying of fruit trees and roadside lalang, although the tractor is not powerful enough to draw the tank over rough ground. A direct attached two-wheeled trailer was also supplied, and has proved useful for carrying loads of up to 10 cwts.

Gem Rotary Hoe.

This machine, a number of which have been in use in Malaya for more than a year, has proved very popular, and for nursery work it is an ideal small machine for cultivation. It possesses the great advantage that surface trash is cut up and mixed well with the soil at the same time as

cultivation takes place; cattle manure can be incorporated with the soil in the same way. Under any sandy soil conditions the tilth produced can often be too fine with the result that after rain the surface " puddles " and sets into a hard crust. Ridging bodies are now available with the machine and with this attachment in use it is possible to cultivate and ridge land in one operation. The maximum depth of cultivation that can be reached is 7 to 9 ins. under good conditions, but where the soil is hard and compacted three runs may be necessary before a cultivated depth of 6 to 7 ins. can be reached. Further details of this rotary hoe can be found in an article in the *Malayan Agricultural Journal*, January, 1948.

Plowmate.

This machine has a 6 h.p. engine and is heavily and robustly made, and is supplied with a general purpose and ley plough, cultivator, discs and Cambridge roll. Although it is capable of doing excellent work under favourable conditions, the tractor has proved heavy to manipulate, especially on turning at headlands. It is fitted with separate brakes to each wheel, but these are of limited use. In particular the ploughs are difficult to adjust to a constant ploughing depth, the most common fault being that of digging in. The discs, cultivators and Cambridge roll were found quite effective, but the general weight of the tractor makes work difficult. The " Cultmate " (3 h.p.) and " Hoemate " (1½ h.p.) are made by the same firm, but are considered too light for use in this country.

Trusty Tractor.

Of similar horse-power to the Plowmate and supplied with plough, discs, cultivators and Cambridge roll, this tractor has proved most useful. The implements are strongly made, and easily attached and detached. The tractor is fitted with a centrifugal clutch and dog clutches to both wheels, features which prevent engine damage in the event of the tractor being overloaded, and make turning at headlands an easier operation. The Trusty appears to be the most satisfactory of all the 5 to 6 h.p. two-wheeled tractors received by the Department.

Ransomes " M.G. 2 " Tractor.

This machine is the smallest track-tractor made in England, with an engine rated at 6 h.p. The operator sits on the machine, and the controls are very simple, consisting of throttle, gear change lever, and twin brake levers through which steering is effected. The clutch is automatic, and engages at engine speeds above 500 r.p.m. The tractor is sturdily constructed throughout, with rubber jointed tracks. It is capable of an immense amount of hard work, and is very manoeuvrable, making it ideal for work in confined spaces.

The implements supplied with this machine consisted of a single-furrow plough, 2-furrow plough, tined cultivator and tandem disc-harrows, but further implements, specially designed for the tractor, are made. The implements themselves are as well built as the tractor.

PLATE V.
Plowmate with discs.

PLATE VI.
Trusty tractor ploughing.

PLATE VII.
Ransomes " M.G. 2 " with tandem discs attached.

PLATE VIII.
Bristol with cultivator attached.

Table I.

Specifications of Tractors.

Tractor	Rated H.P.	Engine Cycle	Cooling	Fuel	No. of Speeds	Wheels	Remarks
Barford "Atom" ..	1.0	Four stroke single cylinder ..	Air	Petrol	One	Single steel	—
Allen Motor Scythe ..	1.5	Two stroke single cylinder ..	Air	Petrol/oil mixture	One	Rubber	—
Lloyds Autosickle ..	2.4	Four stroke single cylinder ..	Air	Petrol	One	Rubber	—
Montgomery Ward ..	3.0	Four stroke single cylinder ..	Air	Petrol	Two	Rubber	Speed adjustment through different sized pulleys.
Waterloo "30" ..	3.2	Four stroke single cylinder ..	Air	Petrol	Three	Rubber	-do-
Autoculto ..	3.6	Two stroke single cylinder ..	Air	Petrol/oil mixture	One	Rubber	—
Clifford Rotary Cultivator ..	4.5	Four stroke single cylinder ..	Air	Petrol/ T.V.O.	One	Steel	—
Gravely ..	5.0	Four stroke single cylinder ..	Air	Petrol	Two forward two reverse	Rubber/ steel	Steel wheels have additional reduction gear.
Gem Rotary Hoe ..	6.0	Four stroke single cylinder ..	Air	Petrol	Three forward	Rubber/ steel	Latest models have reverse gear.
Plowmate ..	6.0	Four stroke single cylinder ..	Air	Petrol	Two forward one reverse	Rubber/ steel	—
Trusty ..	6.0	Four stroke single cylinder ..	Air	Petrol	One	Steel	Latest models have reverse.
Ransomes "M.G. 2" ..	6.0	Four stroke single cylinder ..	Air	Petrol	One forward one reverse	Tracked	Latest model of 7 h.p.
Bristol ..	10.0	Four stroke four cylinders ..	Water	Petrol/ T.V.O.	Three forward one reverse	Tracked	Latest model Bristol "20" utilizes a 16 h.p. engine.

Note—T.V.O. = Tractor vaporising oil.

Table II.

Costs and Time Taken for Various Operations.

Tractor	Operation	Fuel Cost per acre $	Time Taken per acre hours	* Operating Cost per acre $	Remarks
Barford " Atom " ..	Grass-cutting ..	0.35-0.45	1¾-2¼	0.90-1.10	—
Allen Motor Scythe ..	Grass-cutting ..	0.30-0.40	1½-2	0.75-1.00	—
Lloyds Autosickle ..	Grass-cutting ..	1.00-1.20	3 -3½	1.90-2.10	A very versatile machine, but actuating mechanism to knife blade liable to breakage.
Montgomery Ward ..	Ploughing ..	4.90-5.10	11-12	8.00-9.00	Ploughing depth 4-5 ins. Capable of good work on light friable soils only.
	Discing ..	1.40-1.60	2½-3	2.10-2.50	Discs light and of limited use.
Waterloo " 30 " ..	Ploughing ..	4.90-5.10	11-12	8.00-9.00	As for Montgomery Ward.
	Discing ..	1.40-1.60	2½-3	2.10-2.50	-do-
	Mowing ..	1.00-1.20	2½-2¾	1.70-2.00	Rotary type mower, capable of very close cutting.
Autoculto ..	Spraying ..	0.35-0.45 per hour	—	—	Fruit tree spraying at rate of 30-40 trees per hour.
Clifford Rotary Cultivator ..	Rotary cultivating ..	3.10-3.50	7½-8½	4.80-5.20	Cultivating to 6 ins.
	Hoeing ..	0.35-0.45	1½-2	0.75-1.00	—
Gravely ..	Grass-cutting ..	2.50-3.00	1¼-1¾	2.80-3.20	Capable of dealing with heavy grass and weed growths.
	Spraying ..	1.50-2.00 per hour	—	—	Fruit tree spraying at the rate of 30-50 trees per hour.
Gem Rotary Hoe ..	Rotary cultivating ..	5.10-5.70	6¼-7	7.00-7.60	Cultivating to a depth of 5 ins. in one cut only.
Plowmate ..	Ploughing ..	6.00-7.00	8¼-8½	8.20-8.70	Ploughing depth 5-6 ins.
Trusty ..	Ploughing ..	5.20-5.60	6½-7	7.00-7.60	Ploughing depth 6½-7½ ins.
Ransomes " M.G. 2 " ..	Ploughing single furrow ..	4.00-4.50	6¼-6¾	5.50-6.00	Ploughing depth of 7-8 ins. under favourable circumstances.
	Ploughing twin furrow ..	2.25-2.75	4¼-4¾	3.00-3.50	Ploughing depth of 5-5½ ins.
	Cultivating ..	1.10-1.40	1¼-1¾	1.40-1.60	Heavy cultivator penetrating 6 ins.
	Discing ..	1.10-1.40	1¼-1¾	1.40-1.60	Tandem discs producing a good tilth in one run.
	Rolling ..	1.10-1.30	5/6-1 1/6	1.40-1.55	Cambridge roll 3 ft. wide.
Bristol ..	Ploughing two furrow ..	2.60-2.90	4¼-4¾	3.70-4.10	Ploughing depth of 9 ins.
	Cultivating ..	0.90-1.20	½-¾	1.05-1.35	Heavy cultivator reaching 7 ins.
	Rolling ..	0.70-0.90	½-¾	0.85-1.10	Heavy Cambridge roll 4 ft. wide.

* " Operating cost includes the cost of fuel and operator's wages of $1.84 per day, but does not include lubricating oil or any charge for depreciation. Operator's wages are charged on a basis of a 6½ hour day.

The " M.G. 2 " is an extremely versatile tractor, and being light is able to negotiate ground where other tractors would become bogged. Wet soil conditions present no difficulty to it. It can tow trailer loads of 1 ton or more with no difficulty, and it can also be used for towing lawn mowers, spraying equipment etc.

Bristol Tractor.

A small track-tractor, fitted with a standard Austin 10 h.p. engine using petrol to start, and, when warm, running on T.V.O. Like the " M.G. 2 " this machine is manoeuvrable and extremely versatile, but being higher powered it is able to carry out rather heavier work. It is strongly constructed, and simple to operate. The implements supplied with the machine consisted of a 2-furrow plough and a tined cultivator, but other implements are available. This model of the tractor has now been superseded by a more powerful machine, powered by a 16 h.p. Austin engine, which should make it even more suitable for work in this country.

The Bristol has been used for a large variety of tasks since its receipt, including ploughing, rolling, discing, cultivating, carting work with a 3-ton trailer, and spraying. It has given very little mechanical trouble, and should prove suitable for estate work of all kinds.

Summary.

Table I contains particulars of all the tractors mentioned above, while Table II gives the results of tests carried out on friable valley quartzite soils at the Federal Experiment Station, Serdang. Ploughing was carried out on cultivated soil or on ground with a light cover of grasses and weeds. It should be mentioned that these ploughs could not be operated satisfactorily in rough conditions with land under tall grasses or light scrub. In such cases the vegetation would need to be mowed before ploughing was undertaken. Disc-ploughs are not supplied for any of these machines.

MECHANIZATION

Quarterly Progress Report, April to June, 1949.

Compiled by the Acting Chief Field Officer.

Recent Importations.

The following tractors and implements were received during the month and are now undergoing tests:—

Ferguson tractor with associated implements.

McCormick Deering pulveriser Model D.

Byron " L.N.H. " type orchard disc-harrow.

Furrow attachments and soil shredding implements for the " Gem " rotary hoe.

Trenching attachment for Ransome subsoilers C8B and C1E.

McCormick Deering 3-furrow disc-plough for Farmall H tractor.

General.

Tests and modifications carried out in the main padi areas and at the Federal Experiment Station, Serdang, are described elsewhere in this issue.

Federal Experiment Station, Port Swettenham.

This Station, which was previously used mainly for selection work on coconuts, is now being used as a general experiment Station on coastal clays, and mechanical trials of drainage and general cultivation implements are being conducted there.

Killefer 35 R Pan Breaker with 1912 K Ditcher Attachment.

This ditcher has been used in dry weather very successfully. In the specification list it is stated that the power required is 80 h.p. At Port Swettenham it has been drawn by a wide gauge Allis Chalmers H.D.10 of 86 h.p. but the assistance of a subsidiary tractor was frequently required. When working well it was capable of digging 4,000 yards of drain in 4½ hours, that is to say, approximately 40 chains per hour. The drain is 42 ins. wide at the top, 16 ins. wide at the bottom and 26 ins. deep, i.e. it has a cross-section of 0.56 sq. yd. The cost per hour may be calculated as follows:—

	$
Fuel	3.50
Labour: 2 operators and 2 labourers ..	1.96
Depreciation and repairs to 2 tractors ..	9.00
Depreciation and repairs to implements ..	0.90
Total cost per hour	$15.36
Total cost per chain	38.4 cts.

The drains needed a certain amount of cleaning by manual labour. One labourer at $1.64 per day could clean 10 chains per day, i.e. the cleaning of one chain cost 16.4 cts., giving a total for the completed drain of 54.8 cts. per chain equivalent to 4.5 cts. per cubic yard.

Reviews.

BRITISH FARM MECHANIZATION

Published by the Temple Press, Bowling Green Lane, London, E.C.1.
Monthly. Price two shillings.

A new journal on mechanization has recently started publication in the United Kingdom and is mainly designed for overseas readers. The purpose of this journal is stated in its first number as follows:—

" 'British Farm Mechanization' is the overseas counterpart of a journal already well established in the United Kingdom under the title of " Farm Mechanization." Its purpose is to keep farmers, agricultural scientists, and all concerned with the agricultural machinery industry fully informed on every aspect of mechanization."

The first two numbers of this journal have recently come to hand and they give every appearance of constituting a very useful addition to the mechanization journals which are available.

The articles so far published are of a general nature, dealing with such topics as sprayers, disc-ploughs, water-supply machinery, etc. but useful accounts are also given of individual products of the British agricultural engineering industry. For instance the first issue contains a full account of the Fowler Mark VF Tractor and of the Land Rover, while the second describes the David Brown " Cropmaster " and the " Rotavator " for attachment to Fordson tractors.

It is hoped that in future numbers the editors will make a special point of giving descriptive accounts of tractors and implements in use under difficult conditions in tropical countries. Good work under home conditions does not necessarily mean that equipment will give good and lasting service under the very difficult conditions in which they will be required to work in the tropics. What the overseas reader will wish to know is whether the equipment described has been successfully used under conditions which at least approximate to his own.

C. W. S. H.

RUBBER STATISTICS HANDBOOK, 1948.

Published by the Department of Statistics, Federation of Malaya, Kuala Lumpur.
Price $4 (Malayan Currency).

The latest edition of this annual publication follows the lines of previous issues and provides comprehensive statistics of the Malayan rubber industry up to the end of 1948. Separate sections are provided for the Federation of Malaya and for Singapore, in addition to a pan-Malayan section. New tables included give average yields of estate and small-holding rubber, and estate production by nationality of ownership. Percentage figures have been added to amplify certain existing tables.

This handbook forms a valuable work of reference for all interested in the rubber industry.

DEPARTMENTAL NOTES

Retirement of Mr. F. C. Cooke, A.R.C.S., B.Sc., A.M.I.Chem.E.

With the retirement in June of Mr. F. C. Cooke, the Department has lost a keen and energetic officer who did much before the war to assist the small-holding copra industry of Malaya. Mr. Cooke has left for Ceylon to become Director of the Coconut Research Scheme at Lunuwila, in which capacity he will be responsible for the direction of all investigations into coconut products in Ceylon.

Mr. Cooke first came to Malaya in 1929 when he was attached to the Department of Agriculture as an Assistant Chemist for Copra Investigations under the Empire Marketing Board. Subsequently he joined the Department as Chemist (Coconut Products), and in 1941 the title of his post was changed to Chemist, Industrial Processes.

Mr. Cooke visited Ceylon in 1931 to study coconut investigational work there, and he also visited the Philippine Islands in 1934 to report on the coconut industry of that territory. Earlier in the same year he had officiated as Secretary to the Vegetable Oils Committee which, under the Chairmanship of Dr. (now Sir Harold) Tempany, then Director of Agriculture, investigated the economic condition of the coconut and other vegetable oil producing industries of Malaya.

Mr. Cooke was a keen volunteer and was a P.O.W. during the Japanese occupation. On his return to Malaya in 1946 he became Canning Research Officer, a post in which he had previously acted in 1940, and he has been actively concerned with the rehabilitation of the important pineapple canning industry of Malaya. In 1948 he visited Hawaii to study the pineapple canning industry of those Islands, and his report on that visit is now in the press.

His colleagues in the Department all join in offering their congratulations to Mr. Cooke on his new appointment and in wishing him success in the important work now entrusted to him. They also offer their sincere wishes to both Mr. and Mrs. Cooke for their happiness in their new life in Ceylon.

H. L. B.

Regional Research Organisation.

Mr. R. G. Simmons, C.B.E., Adviser on Animal Health to the Secretary of State for the Colonies, and Dr. A. E. S. McIntosh, Deputy Director of Agriculture, Federation of Malaya, were appointed by the Secretary of State for the Colonies as a Mission to review the research requirements of Malaya, North Borneo and Sarawak, and to report and make recommendations to the Secretary of State as to how these requirements might best be met on a regional basis.

Mr. Simmons and Dr. McIntosh arrived in Malaya in April, and have visited all the territories concerned in this possible new development in research organisation. They return to London this month (July) to present their report.

An abstract of a Report by the Committee for Colonial Agricultural, Animal Health and Forestry Research was published in the April issue of this Journal.

Visit of Mechanization Experts.

Dr. E. W. Russell, a soil physicist at the University of Oxford, and Mr. J. C. Hawkins, an authority on ploughing and cultivation implements at the National Institute of Agricultural Engineering, have been appointed by the Secretary of State for the Colonies to visit Malaya to advise on mechanization in relation to rice cultivation.

Dr. Russell and Mr. Hawkins arrived in Singapore on 13th July, 1949, and will remain in Malaya about six weeks, visiting the various centres in which the Department of Agriculture is carrying out its investigations into mechanical cultivation.

Appointments.

Mr. R. G. Heath, Senior Agricultural Officer, has been appointed to act as Director of Agriculture, Federation of Malaya, with effect from 23rd April, 1949.

Mr. E. J. H. Berwick, Agricultural Officer, has been appointed to act as Chief Field Officer, Department of Agriculture, with effect from 23rd April, 1949.

Mr. J. K. Coulter, Chemist (Soils), has been appointed to act as Senior Chemist, Department of Agriculture, with effect from 21st April, 1949.

Mr. E. F. Allen, Agricultural Officer, has been appointed to act as State Agricultural Officer, Perak, with effect from 25th April, 1949.

Che Zakaria bin Abdul Rauf, Malay Agricultural Officer, has been appointed to act as State Agricultural Officer, Selangor, with effect from 23rd April, 1949.

Mr. L. N. H. Larter, Botanist, has been appointed to act as Senior Botanist, Department of Agriculture, with effect from 20th May, 1949.

Mr. A. Johnston, Plant Pathologist, has been appointed to act as Senior Plant Pathologist, Department of Agriculture, with effect from 26th May, 1949.

Promotion.

The Right Honourable the Secretary of State for the Colonies has been pleased to approve the promotion of Dr. S. G. Willimott, Chemist, (Soils), Malayan Agricultural Service, to be Senior Chemist, (Soils), Malayan Agricultural Service, with effect from 1st January, 1948.

Leave.

Mr. R. G. H. Wilshaw, Chief Research Officer and Acting Director of Agriculture, has been granted 180 days leave in addition to voyages, with effect from 23rd April, 1949.

H. H. Tengku Yaacob ibni al-marhum Sultan Abdul Hamid, C.M.G., Senior Agricultural Officer and Acting Deputy Director of Agriculture, has been granted 228 days leave with effect from 21st April, 1949.

Mr. J. Fairweather, M.B.E., Senior Agricultural Officer, has been granted 130 days leave, in addition to voyages, with effect from 25th April, 1949.

Mr. A. Thompson, Senior Plant Pathologist, has been granted 130 days leave, in addition to voyages, with effect from 26th May, 1949.

Mr. R. B. Jagoe, Senior Botanist, has been granted 143 days leave, in addition to voyages, with effect from 21st May, 1949.

Mr. Gunn Lay Teik, O.B.E., Chemist, has been granted 160 days leave with effect from 21st April, 1949.

Dr. S. G. Willimott, Senior Chemist, (Soils), has been granted 137 days leave, in addition to voyages, with effect from 2nd May, 1949.

Publications of the Department of Agriculture.

For reasons of economy the advertisement pages of this Journal listing the Special Bulletins of the Department have been excluded, but full particulars of all available publications can be obtained from the Department of Agriculture, P.O. Box 1004, Kuala Lumpur.

A new Special Bulletin, No. 23 in the Scientific Series, was published in June entitled " Malayan Food Composition Table " by Dr. S. G. Willimott, Senior Chemist (Soils). This Bulletin provides in tabular form the percentage composition of the uncooked edible portion of the principal staple foodstuffs used in Malaya. It is considered that the information now made available will supply a need which is being increasingly encountered in nutrition studies in Malaya and elsewhere. The price of the Bulletin is $2 post free.

Malayan Agricultural Statistics, 1947, Special Bulletin, No. 13 Economic Series, which has been considerably delayed in the press should be available from the printers in September. It will be on sale at $5 post free, and is the first edition of this former popular compilation of statistics to be published since the war. It provides a complete picture of Malayan agriculture statistically: acreages, production, imports and exports, and prices, with tables extending back to 1923 or earlier in some cases.

The serious shortage of senior officers has delayed the revision of the numerous Agricultural Leaflets which are at present out of print, but it is hoped that revised editions will shortly be available. New leaflets now in preparation deal with cocoa and ramie, and a new Mechanization Series is planned, the first of which will cover horticultural tractors.

Statistical.

MARKET PRICES

April to June 1949.

Rubber.—The Singapore price of No. 1 R.S.S. f.o.b., in bales, remained fairly constant during April. Opening at 36½ cents per lb., it dropped to 35½ cents by the end of the month with an average for April of 35.80 cents. In May the price remained between 35 and 36 cents for the first three weeks but by 31st May had dropped to 31⅞ cents giving an average of 34.77 cents per lb. The price increased by ⅜ cent on the 1st June and remained fairly steady during the month. The average price for June was 32.21 cents.

The average prices paid in London and New York were: London, April 10.74, May 10.69 and June 9.21 pence per lb.: New York, April 18.51, May 17.92 and June 16.34 cents gold per lb.

The average prices paid for small-holders' rubber at three centres during the second quarter of 1949 are given in Table I.

Table I.

Average Monthly Prices Paid by Local Dealers for Small-Holders' Rubber, April-June, 1949.

(Dollars per picul of 133⅓ lbs.)

Grades	Taiping Perak.			Seremban Negri Sembilan.			Batu Pahat, Johore.		
	April	May	June	April	May	June	April*	May	June
Smoked Sheet ..	41.00	41.50	40.50	43.60	40.90	39.00	38.63	37.25	34.50
Unsmoked Sheet ..	35.00	35.00	29.50	36.50	33.50	30.00	35.50	34.50	32.50
Scrap ..	12.50	12.50	12.00	14.00	13.00	14.00	23.50	11.75	12.25

Transport from Batu Pahat to Singapore by lorry, excluding duty, $1 per picul.

* First 2 weeks only.

Tea.—The average price in Colombo for Malayan teas, as quoted in the Colombo Brokers' Association weekly report dated 26th July, 1949, was Rs. 1.96 per lb. The average prices of Ceylon teas were as follows, in rupees per lb.: High Grown Teas Rs. 2.04, Medium Grown Teas Rs. 1.83, Low Grown Teas Rs. 1.90.

Ceylon teas are subject to an export duty but non-Ceylon teas sold at auctions ex-bond in Colombo for re-export are not subject to this duty.

The retail price of Malayan tea (Boh) has remained at $2 per lb.

Palm Oil.—The majority of Malayan estate production of this commodity continues to be sold to the United Kingdom Ministry of Food. There has been no change in the price payable to producers of £82 per ton f.o.b. Malayan ports. The 5 per cent. *ad valorem* Malayan export duty is for buyers account.

Derris.—The decline in price in February continued during March when the average price per picul of 5 per cent. rotenone root was $68 to $70. There was a further decline in April and May to $65 to $67 per picul.

Rice.—The rice ration in the Federation of Malaya has remained at 3 katis per person per week. The controlled price of rice has decreased from $30 to $28 per picul.

Tobacco.—The prices paid per picul for cured leaf in Kelantan during the 2nd quarter 1949, were as follows:—1st quality $200 to $400, 2nd quality $150 to $300 and 3rd quality $100 to $200.

Table II.

Singapore Prices of Various Agricultural Products.

(per picul)

Product	June, 1949			May, 1949	April, 1949	Average Price 1948
	Highest	Lowest	Average	Average	Average	
	$	$	$	$	$	$
Copra:						
Sundried No. 1 ..	29.00	27.25	27.99	28.71	28.76	38.77
Coconut Oil ..	52.00	49.00	50.18	52.92	52.85	68.74
Coffee:						
Padang Bali No. 1	*	*	*	*	168.00	115.35
Palembang No. 1	*	*	*	*	80.00	72.19
Sourabaya No. 1	*	*	*	*	94.00	82.32
Pepper:						
Muntok White ..	404.00	370.00	392.80	350.00	296.42	181.63
Sarawak ..	403.00	369.00	391.80	349.00	295.42	180.62
Gambier:						
Rounds No. 1 ..	145.00	145.00	145.00	135.83	*	127.22†
Sago Flour:						
Lingga ..	13.50	11.00	11.23	14.44	13.83	18.55
Tapioca Flour:						
Malayan No. 1 ..	18.00	18.00	18.00	18.74	22.76	30.48

* Not quoted. † Average January-November.

FEDERATION OF MALAYA
PRODUCTION OF PALM OIL AND KERNELS.

(In long tons as declared by Estates)

Month	Palm Oil		Palm Kernels	
	1948	1949	1948	1949
January ..	3,821.9	3,793.0	664.1	799.9
February ..	3,659.8	4,007.0	677.9	821.4
March ..	3,567.6	4,055.6	633.0	860.1
April ..	3,598.6	3,999.3	699.4	808.3
May ..	3,076.5	4,120.9	597.4	809.2
June ..	2,420.1	4,321.5	431.0	791.2
July ..	3,245.5	4,461.3	564.9	931.0
August ..	3,617.8		690.2	
September ..	4,283.4		827.2	
October ..	4,376.6		899.4	
November ..	4,827.2		913.6	
December ..	4,762.4		873.0	
Total ..	45,257.4	(28,758.6)	8,471.1	(5,821.1)

In July 44 estates (planted area 81,576 acres) were in production out of a total of 51 oil palm estates (planted area 84,082 acres).

MALAYAN AGRICULTURAL EXPORTS, JANUARY-MARCH, 1949.

Product	Net Exports in Tons.			
	Year 1947	Year 1948	Jan.-Mar. 1948	Jan.-Mar. 1949
Arecanuts	12,507	6,043	1,276*	3,233
Coconuts fresh†‡ ..	62,873†	44,887†	11,661†	525†
Coconut oil‡	41,112	45,245	11,984	11,257
Copra‡	45,439*	28,625*	14,117*	4,076*
Copra cake	5,260*	12,176*	635*	5,270*
Gambier, all kinds ..	1,156	286	6*	44
Palm kernels	5,245	6,462	1,449	2,001
Palm Oil	43,325	46,821	9,238	18,425
Pineapples, canned ..	2,611	4,073	974	1,497
Rubber¶	645,229¶	696,978¶	171,076¶	173,530¶
Sago,—flour	5,958	16,946*	1,915*	186*
„ —pearl	2,404	19,084	1,755	1,976
„ —raw	6,415*	6,667*	237*	720*
Tapioca,—flake	52	304	16	115
„ —flour	6,490	1,999*	12*	259*
„ —pearl	7,205	14,263	1,650	416
Derris	243	80	29	3
‡Copra equivalent ..	22,625	45,795	5,590	14,288

¶ production (Federation of Malaya). † hundreds in number. * net imports.

FEDERATION OF MALAYA.

PADI SEASON 1948-1949.

Acreages of WET PADI harvested monthly and Estimated Yields.

State/Settlement (1)	Total planted area Acres (2)	Total to 30th June, 1949			July, 1949			Total to 31st July, 1949		
		Area Harvested Acres (3)	Per cent (3)-(2) (4)	Estimated Average Yield per acre (gantangs) (5)	Area Harvested Acres (6)	Per cent (6)-(2) (7)	Estimated Average Yield per acre (gantangs) (8)	Area Harvested Acres (9)	Per cent (9)-(2) (10)	Estimated Average Yield per acre (gantangs) (11)
Perlis ..	43,430 (a)	35,052	80.70	207	Harvest Completed			35,052	80.70	207
Kedah ..	273,204 (b)	231,700	84.81	219	-do-			231,700	84.81	219
Kelantan ..	141,555 (c)	140,272	99.09	266	-do-			140,272	99.09	266
Trengganu ..	44,105 (d)	43,950	99.65	261	-do-			43,950	99.65	261
Penang & P. Wellesley	39,403 (e)	35,532	90.17	183	-do-			35,532	90.17	183
Perak ..	119,369 (f)	118,589	99.35	271	-do-			118,589	99.35	271
Selangor ..	41,851	30,245	72.27	357	8,505	20.32	178	38,750	92.59	318
Pahang ..	46,737	39,800	85.16	186	Harvest Completed			39,800	85.16	186
N. Sembilan ..	34,291	34,291	100.00	302	-do-			34,291	100.00	302
Malacca ..	31,812 (g)	29,186	91.74	235	-do-			29,186	91.74	235
Johore ..	20,709 (h)	20,195	97.52	178	-do-			20,195	97.52	178
Total ..	836,466	758,812	90.72	243	8,505	1.02	178	767,317	91.73	243

(a) 8,378 acres destroyed by drought; (b) 41,504 acres destroyed by drought; (c) 1,283 acres destroyed by sea water, late planting and dry weather; (d) 155 acres destroyed by sea water and rats; (e) 3,871 acres destroyed by drought; (f) 550 acres destroyed by drought, 230 acres abandoned due to bandit activity; (g) 2,626 acres destroyed by drought, pests and flood; (h) 514 acres destroyed by floods and pests.

FEDERATION OF MALAYA.

PADI SEASON 1948-1949.

Acreages of DRY PADI harvested monthly and Estimated Yields.

State/Settlement (1)	Total planted area Acres (2)	Total to 30th June, 1949			July, 1949			Total to 31st July, 1949		
		Area Harvested Acres (3)	Per cent (3)-(2) (4)	Estimated Average Yield per acre (gantangs) (5)	Area Harvested Acres (6)	Per cent (6)-(2) (7)	Estimated Average Yield per acre (gantangs) (8)	Area Harvested Acres (9)	Per Cent (9)-(2) (10)	Estimated Average Yield per acre (gantangs) (11)
Perlis ..	64	64	100.00	141	Harvest Completed			64	100.00	141
Kedah ..	4,190(a)	4,051	96.68	101		-do-		4,051	96.68	101
Kelantan ..	32,213(b)	31,628	98.19	133		-do-		31,628	98.19	133
Trengganu ..	10,364	10,364	100.00	133		-do-		10,364	100.00	133
Penang & P. Wellesley	1,793(c)	1,710	95.37	120		-do-		1,710	95.37	120
Perak ..	9,853(d)	9,216	93.53	100		-do-		9,216	95.53	100
Selangor ..	1,490(c)	1,164	78.12	155		-do-		1,164	78.12	155
Pahang ..	2,724	2,724	100.00	136		-do-		2,724	100.00	136
N. Sembilan ..	23	23	100.00	35		-do-		23	100.00	35
Malacca ..	61	61	100.00	169		-do-		61	100.00	169
Johore ..	2,401(f)	2,333	97.13	78		-do-		2,333	97.13	78
Total ..	65,176	63,338	97.18	124		-do-		63,338	97.18	124

(a) 139 acres destroyed by drought and pests; (b) 585 acres destroyed by pests and late planting; (c) 83 acres destroyed by drought; (d) 487 acres destroyed by drought and pests, 150 acres abandoned due to bandit activity; (e) 326 acres not harvested due to late planting and pest damage; (f) 68 acres destroyed by pests.

FEDERATION OF MALAYA RUBBER PRODUCTION.

(In long tons, dry weight)

Month	Estates		Small-holdings (Estimated)		Total	
	1948	1949	1948	1949	1948	1949
January ..	34,668	36,397	27,321	24,052*	61,989	60,449*
February ..	28,529	27,593	22,121	17,450*	50,650	45,043*
March ..	31,888	33,616	26,549	20,309*	58,437	53,925*
				14,113†		14,113†
April ..	32,724	28,142	33,684	16,744	66,408	44,886
May ..	33,294	33,570	16,313	18,499	49,607	52,069
June ..	33,246	32,921	27,348	18,683	60,594	51,604
				2,705†		2,705†
July ..	35,193	35,751	22,972	20,137	58,165	55,888
August ..	33,727		22,875		56,602	
September ..	33,292		30,910		64,202	
October ..	34,020		16,347		50,367	
November ..	34,149		27,822		61,971	
December ..	38,177		19,809		57,986	
Total ..	402,907	(227,990)	294,071	(152,692)	696,978	(380,682)
Total 1947 ..	359,865		285,364		645,229	

Small-holding production is estimated from purchases reported by dealers; prior to 1949 it was estimated from the formula: Production + imports + opening stocks = exports + consumption + closing stocks.

* Amended figures.

† Quarterly adjustment.

FEDERATION OF MALAYA

PRODUCTION OF COPRA, COCONUT OIL AND COPRA CAKE.

(in tons)

Month	Copra Production						Coconut Oil Production		Copra Cake (Poonac) Manufactured	
	Estates		Small-holdings (estimated)		Total		Oil Mills		Oil Mills	
	1948	1949	1948	1949	1948	1949	1948	1949	1948	1949
January ..	—	2,476	—	7,406	—	9,882	3,302	4,727	2,512	3,245
February ..	—	2,605	—	5,544	—	8,149	3,224	4,429	2,432	3,027
March ..	—	2,644	—	4,981	—	7,625	3,910	4,638	2,913	3,211
April ..	—	2,755	—	6,203	—	9,204	4,054	4,832	3,223	3,325
May ..	—	3,039	—	5,884	—	8,923	3,124	4,995	2,446	3,437
June ..	—	3,500	—	6,723	—	10,223	3,729	5,607	2,955	3,756
July ..	2,971		2,619		5,590		3,625	5,710	2,901	3,870
August ..	3,227		8,731		11,958		4,556		3,484	
September ..	3,326		7,077		10,403		5,266		3,730	
October ..	3,371		10,037		13,408		5,535		3,933	
November ..	2,992		8,377		11,369		5,096		3,669	
December ..	3,124		8,767		11,891		5,743		3,772	
Total ..	(19,011)		(45,608)		(64,619)		51,164		37,970	

Notes:—1. The above statistics are compiled and published by the Registrar of Statistics, Federation of Malaya.

2. Estate copra production and coconut oil production are as declared by estates and oil mills respectively.

3. Statistics of small-holding coconut oil production are not available.

4. Small-holding copra production for commercial purposes is estimated from the formula: imports + estate stocks (opening) + estate production + small-holding production = exports + local oil mill consumption + estate stocks (closing).

5. Statistics of copra production prior to July, 1948, are not available.

METEOROLOGICAL SUMMARY, MALAYA, MARCH, 1949.

Locality	Air Temperature degrees Fahrenheit							Earth Temperature		Rainfall									Bright Sunshine		
	Means of			Absolute Extremes									Number of days								
	A. Max.	B. Min.	Means of A and B	Highest Max.	Lowest Min.	Lowest Max.	Highest Min.	At 1 foot °F	At 4 feet °F	Total	Most in a day Amt.		Precipitation .01 in or more	Precipitation .04 in or more	Thunderstorm	Fog morning obs.	Gale force 8 or more		Total	Daily Mean	Per cent.
										ins.	m.m.	ins.									
Ipoh, Perak ..	93.3	72.0	82.7	96	69	89	75			5.36	136.1	1.07	16	15	7		1				
Port Swettenham, Selangor	90.4	72.1	81.3	94	69	83	76	86.2	85.7	8.13	206.5	1.48	16	13	7	2			208.90	6.74	
K. Lumpur, Selangor ..	91.5	72.8	82.1	96	71	86	75			12.65	321.3	3.11	20	19	13	8					
Sitiawan, Perak ..	89.2	72.7	80.9	92	70	86	75	84.6		3.74	95.0	1.20	19	10	5	2			214.05	6.90	
Kuantan, Pahang ..	90.0	70.1	80.1	94	67	84	73			5.97	151.6	1.24	12	10		1			237.80	7.67	
Kuala Lipis, Pahang ..	89.7	71.6	80.7	92	68	81	74	84.4	84.0	2.90	73.7	0.77	12	10	5	24			219.25	7.07	
Temerloh, Pahang ..	–	72.7	–	–	69	–	75			4.46	113.3	1.08	13	9		5			235.10	7.58	
Bayan Lepas, Penang ..	89.2	74.7	81.9	92	70	87	78			6.35	161.3	2.69	10	7		26			263.90	8.51	
Malacca ..	89.5	73.8	81.7	93	70	86	76			4.34	110.2	1.00	12	9	3				252.20	8.13	
Mersing, Johore ..	85.5	73.4	79.5	88	70	81	78			2.48	63.0	0.99	10	7	3				287.20	9.26	
Alor Star, Kedah ..	93.5	71.7	82.6	96	67	90	74			5.60	142.2	1.43	10	8	6				274.10	8.84	
Kota Bharu, Kelantan ..	72.4	–	–	–	69	–	75	86.9		1.71	43.4	0.81	8	7		3					
K. Trengganu, Trengganu	72.3	–	–	–	70	–	75			4.03	102.4	0.79	14	11	2	7			245.50	7.92	
HILL STATIONS.																					
Fraser's Hill, Pahang 4268 ft. ..	73.2	62.0	67.6	77	58	69	64	71.9		6.77	172.0	2.44	18	13		22					
Cameron Highlands, Tanah Rata, Pahang 4750 ft.	73.4	52.9	63.1	77	47	67	62	66.4	68.7	4.54	115.3	0.83	16	15		1			173.45	5.59	

Compiled from Returns supplied by the Malayan Meteorological Service.

METEOROLOGICAL SUMMARY, MALAYA, APRIL, 1949.

Locality	Air Temperature degrees Fahrenheit							Earth Temperature		Rainfall									Bright Sunshine		
	Means of			Absolute Extremes									Number of days								
	A. Max.	B. Min.	Means of A and B	Highest Max.	Lowest Min.	Lowest Max.	Highest Min.	At 1 foot °F	At 4 feet °F	Total		Most in a day Amt.	Precipitation .01 in or more	Precipitation .04 in or more	Thunderstorm	Fog morning obs.	Gale force 8 or more		Total	Daily Mean	Per cent.
										ins.	m.m.	ins.									
Ipoh, Perak ..	91.7	73.6	82.7	95	71	87	75			6.96	176.8	1.71	22	20	1						
Port Swettenham, Selangor	90.1	74.1	82.1	93	72	85	77	85.9	85.7	10.81	274.6	3.86	22	16	1	1			190.70	6.36	
K. Lumpur, Selangor ..	90.9	74.2	82.5	94	71	84	76			12.77	324.4	2.73	25	19	6	7					
Sitiawan, Perak ..	88.9	73.7	81.3	91	72	82	76	85.3		10.28	261.1	2.03	21	14	7	2			207.60	6.92	
Kuala Lipis, Pahang .	89.7	72.7	81.2	93	70	82	75	84.7	84.6	7.69	195.3	1.84	17	15	3	17			170.15	5.67	
Kuantan, Pahang ..	89.7	71.7	80.7	93	66	82	75			8.16	207.3	2.71	23	15		11			171.95	5.73	
Temerloh, Pahang ..	–	74.0	–	–	72	–	76			5.74	145.8	1.65	23	16	1	2			178.20	5.94	
Bayan Lepas, Penang .	88.2	75.9	82.1	91	73	86	78			10.41	264.4	2.73	20	18	17				220.25	7.34	
Malacca ..	87.0	74.2	80.6	91	72	82	77			9.83	249.7	2.00	20	18					187.90	6.26	
Mersing, Johore ..	86.5	73.0	79.7	89	71	79	75			9.20	233.7	2.21	24	22	3	3			186.25	6.21	
Alor Star, Kedah .	91.0	73.9	82.5	95	72	86	75			15.06	382.5	3.24	22	20	9	1			227.00	7.57	
Kota Bharu, Kelantan ..	–	74.1	–	–	72	–	77	88.1		2.77	70.4	1.23	9	7	2	3					
K. Trengganu, Trengganu	–	73.5	–	–	71	–	75			4.09	103.9	1.61	9	6	3				231.30	7.71	
HILL STATIONS																					
Fraser's Hill, Pahang 4268 ft. ..	74.5	62.9	68.7	77	61	71	64	72.7		11.07	281.2	1.60	27	19	2	12			129.20	4.31	
Cameron Highlands, Tanah Rata, Pahang 4750 ft.	74.3	56.0	65.1	77	50	71	61	68.3	69.3	14.92	379.0	1.73	23	23		3			126.05	4.20	

Compiled from Returns supplied by the Malayan Meteorological Service.

METEOROLOGICAL SUMMARY, MALAYA, MAY, 1949.

Locality	Air Temperature degrees Fahrenheit							Earth Temperature		Rainfall									Bright Sunshine		
	Means of			Absolute Extremes								Most in a day	Number of days								
	A. Max.	B. Min.	Means of A and B	Highest Max.	Lowest Min.	Lowest Max.	Highest Min.	At 1 foot °F	At 4 feet °F	Total		Amt.	Precipitation .01 in or more	Precipitation .04 in or more	Thunderstorm	Fog morning obs.	Gale force 8 or more		Total	Daily Mean	Per cent.
										ins.	m.m.	ins.							hr.	hr.	
Ipoh, Perak ..	92.2	73.5	82.9	96	71	85	76			10.88	276.4	2.18	16	12	2						
Port Swettenham, Selangor	90.2	74.1	82.1	94	72	86	77	86.6	86.6	3.53	89.7	0.57	17	13	5	2			221.30	7.14	
K. Lumpur, Selangor ..	90.4	74.5	82.5	94	72	86	77			11.53	292.9	2.83	20	15	3	4					
Sitiawan, Perak ..	89.3	73.6	81.5	91	72	85	75	85.7		4.17	105.9	0.61	16	15	2	3			225.75	7.28	
Kuala Lipis, Pahang ..	89.5	72.3	80.9	92	69	86	75	84.5	84.5	9.98	253.5	2.64	18	14	2	26			184.70	5.96	
Kuantan, Pahang ..	89.8	72.6	81.2	93	70	86	75			6.09	154.7	1.32	20	17	2	13			177.05	5.71	
Temerloh, Pahang ..	–	73.8	–	–	70	–	76			7.65	194.3	2.54	20	17	2	4			181.05	5.84	
Bayan Lepas, Penang ..	87.9	75.3	81.6	90	73	84	77			9.50	241.3	3.01	23	18	6		1		197.80	6.38	
Malacca ..	85.0	74.3	80.1	88	73	83	78			8.16	207.3	2.02	18	13					220.00	7.10	
Mersing, Johore ..	87.5	72.7	80.1	91	71	78	75			5.96	151.4	1.02	19	17	7	1			196.40	6.32	
Alor Star, Kedah ..	88.9	75.1	82.0	92	73	83	77			12.39	314.7	2.40	24	22	4				215.46	6.95	
Kota Bharu, Kelantan ..	–	74.6	–	–	73	–	77	88.3		3.24	82.3	1.44	12	12	3	1			248.65	8.02	
K. Trengganu, Trengganu	–	74.0	–	–	71	–	76			6.77	172.0	1.35	19	5	6				217.25	7.01	
HILL STATIONS.																					
Fraser's Hill, Pahang 4268 ft. ..	75.2	63.5	69.3	78	62	72	65	72.8		15.26	387.6	2.50	22	19	5	8			174.90	5.64	
Cameron Highlands, Tanah Rata, Pahang 4750 ft.	73.9	56.2	65.1	78	53	71	61	69.1	70.0	14.27	362.5	2.74	25	20	1	4			143.20	4.62	

Compiled from Returns supplied by the Malayan Meteorological Service.